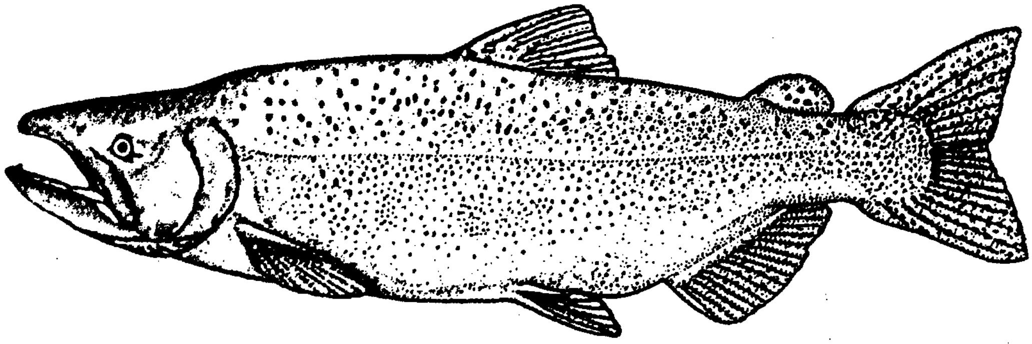
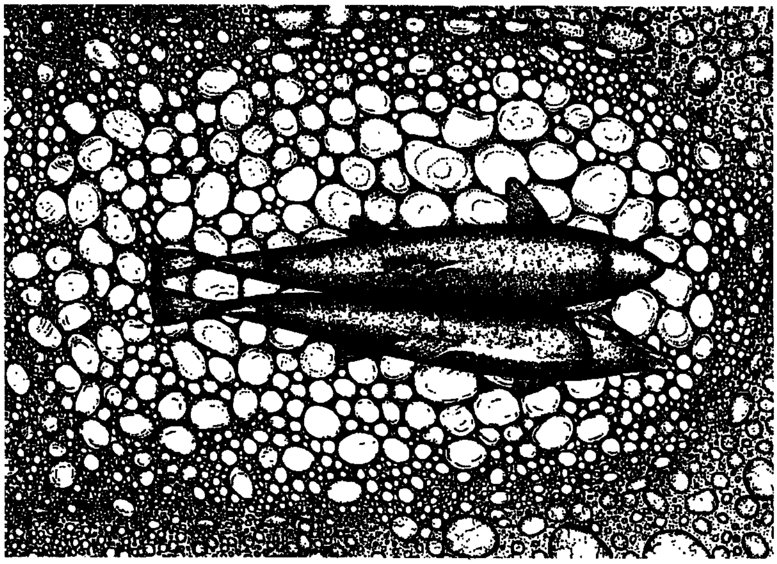
EFFECTS OF THE JANUARY 1997 FLOOD ON FLOW-HABITAT RELATIONSHIPS FOR STEELHEAD AND FALL-RUN CHINOOK SALMON SPAWNING IN THE LOWER AMERICAN RIVER





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Prepared by staff of
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CVPIA INSTREAM FLOW INVESTIGATIONS
EFFECTS OF THE JANUARY 1997 FLOOD ON LOWER AMERICAN RIVER STEELHEAD AND FALL-RUN CHINOOK SPAWNING

PREFACE

The following is the final report for the U. S. Fish and Wildlife Service's investigations on the effects of the January 1997 flood on the flow-habitat relationships for steelhead and fall-run chinook salmon spawning in the Lower American River, part of the Central Valley Project Improvement Act (CVPIA) Instream Flow Investigations, a 7-year effort which began in February, 1995. Title 34, Section 3406(b)(1)(B) of the CVPIA, P.L. 102-575, requires the Secretary of the Interior to determine instream flow needs for anadromous fish for all Central Valley Project controlled streams and rivers, based on recommendations of the U. S. Fish and Wildlife Service after consultation with the California Department of Fish and Game (CDFG). The purpose of these investigations are to provide scientific information to the U. S. Fish and Wildlife Service Central Valley Project Improvement Act Program to be used to develop such recommendations for Central Valley rivers.

To those who are interested, comments and information regarding this report are welcomed. Written comments or information can be submitted to:

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INTRODUCTION

In response to substantial declines in anadromous fish populations, the Central Valley Project Improvement Act requires the doubling of the natural production of anadromous fish stocks, including the four races of chinook salmon (fall, late-fall, winter, and spring runs), steelhead, and white and green sturgeon. For the Lower American River, the Central Valley Project Improvement Act Anadromous Doubling Plan calls for October through February (during fall-run chinook salmon spawning) flows at the H Street Bridge ranging from 1750 cfs in critically dry years to 2500 cfs in wet years (U.S. Fish and Wildlife Service 1995). In December 1994, the U. S. Fish and Wildlife Service prepared a study proposal to identify the instream flow requirements for anadromous fish in certain streams within the Central Valley of California, including the Lower American River. The purpose of this study was to produce models predicting the hydraulic and structural characteristics of spawning sites for steelhead and fall-run chinook salmon over a range of stream flows.

The original study was a one year effort which culminated in a March 27, 1996 report detailing the methods and results of this effort. This report was submitted to CDFG for enclosure in their final report on the Lower American River. Subsequently, questions arose as to which of the fall-run chinook salmon spawning habitat suitability criteria (HSC) used in the March 27, 1996 report would be transferable to the Lower American River. As a result, additional field work was conducted in FY97, culminating in a supplemental report submitted to CDFG on February 11, 1997. As a result of substantial changes in the Lower American River study sites from severe storms in January 1997, a second round of habitat data collection and modeling was begun in April 1998. Data collection for this effort was completed by February 1999, with data analysis from that work resulting in this report. The results of this study are intended to show whether the January 1997 flood changed the flow-habitat relationship for steelhead and fall-run chinook salmon spawning in the Lower American River.

METHODS

Study Site Selection

In January 1997, 115,000 cfs flood releases were made into the Lower American River. Considerable morphological changes occurred in many areas of the river including some of the sites used in the March 1996 study. As a result of these changes, CDFG requested that we collect additional hydraulic and structural data, and develop new spawning habitat models for the river. The modeling used PHABSIM, the Physical Habitat Simulation component of the IFIM, which is the collection of one dimensional hydraulic and habitat models which are used to predict the relationship between physical habitat availability and streamflow over a range of river discharges.

Sites were selected based on CDFG aerial photos of fall 1997 chinook salmon redds in the Lower American River. The five areas with the highest concentration of redds were chosen as sites (Table 1). Each site was evaluated based on morphological and channel characteristics which facilitate the development of reliable hydraulic models. Also noted were riverbank and floodplain characteristics (e.g. steep, heavily vegetated berms or gradually sloping cobble benches) which might affect our ability to collect the necessary data to build these models.

Table 1
Sites Selected for Modeling Chinook Salmon Spawning

Site Name	Number of Transects
Sailor Bar	4
Above Sunrise	7
Sunrise	7
El Manto	2
Rossmoor	7

Transect Placement (study site setup)

A total of 27 PHABSIM transects were placed in the five study sites in April 1998. At each site, transects were located such that they crossed the areas most heavily used by spawning fall-run chinook salmon in 1997. Transect head and tail pins were marked on each river bank above the 12,000 cfs water surface level using rebar driven into the ground and/or lag bolts placed in stumps. Survey flagging was used to mark the locations of each pin. The study sites and number of transects are shown in Table 1.

Hydraulic and Structural Data Collection

Vertical benchmarks were established at each site to serve as the reference elevations to which all elevations (streambed and water surface) were tied. Vertical benchmarks consisted of lag bolts driven into trees. The data collected on each transect included: 1) water surface elevations (WSELs), measured to the nearest 0.01 foot at three significantly different stream discharges using standard surveying techniques (differential leveling); 2) wetted streambed elevations determined by subtracting the measured depth from the surveyed WSEL at a measured flow; 3) dry ground elevations to points above bankfull discharge surveyed to the nearest 0.1 foot; 4) mean water column velocities measured at a mid-to-high-range flow at the points where bed elevations were taken; and 5) substrate and cover classification at these same locations and also where dry ground elevations were surveyed. Data collection for input into PHABSIM was begun in April 1998 and completed in February 1999.

Water surface elevations were measured at all sites at the following flows (see also Table 2): at 1040 cfs (Sept 10), at 2028 cfs (Sept 9), at approximately 3000 cfs (Nov 12 – Dec 1), at approximately 4000 cfs (Jul 14 and Aug 5), at approximately 7500 cfs (Apr 6 – May 21), and at approximately 11000 cfs (May 7-15). Additionally, WSELs were measured at approximately 9000 cfs at Sailor Bar and Above Sunrise (May 20). In most cases, WSELs were measured on both banks of each transect. If the WSELs on the two banks differed by more than 0.10 feet, a note was made as to which WSEL was most representative of the transect.

Depth and velocity measurements for velocity sets to be used in PHABSIM were collected for all sites at approximately 3000 cfs (Nov 13 - Dec 1). Depth and velocity measurements to compute discharges were collected for transects with split channels, to develop regression equations between split channel and total discharge, at 1040 cfs (Sept 10), at approximately 2000 cfs (Oct 22-30), at approximately 4000 cfs (Jul 13 - Sept 16), at 7617 cfs (May 21), at approximately 9000 cfs (May 20), and at 11107 cfs (May 15).

Depth and velocity measurements in shallow portions of the transects were made by wading with a top-setting wading rod equipped with a Marsh-McBirney[R] model 2000 or a Price AA velocity meter. In areas with depths greater than three feet, measurements were made with a jet boat equipped with a Broad-Band Acoustic Doppler Current Profiler (ADCP). Starting at the water's edge, water depths and velocities were made at measured intervals using the wading rod and velocity meter until the water became sufficiently deep to operate the ADCP. The distance intervals between each depth and velocity measurement from the headpin or tailpin were measured using a hand held laser range finder[1]. At the location of the last depth and velocity measurement made while wading, a buoy was placed to serve as a starting point for the ADCP. The boat was then positioned so that the ADCP started operation at the buoy, and water depth and velocity data were collected across the transect up to the location near the opposite bank where water depths of approximately 3 feet were reached. A buoy was placed at the location where ADCP operation ceased and the procedure used for measuring depths and velocities in shallow water was repeated until the far bank water's edge was reached. Typically three ADCP runs were made for each transect and flow.

Substrate classification was accomplished visually on dry land and in shallow water, and using underwater video equipment along the deepwater portion of the transects. The underwater video equipment consisted of two waterproof remote cameras mounted on an aluminum frame with two 30 lb lead bombs. One camera was mounted facing forward, depressed at a 45° angle from the horizontal, and the second camera was mounted such that it faced directly down at a 90° angle from the horizontal. The camera mounted at a 45° angle was used for distinguishing changes in substrate size classes, while the camera mounted at 90° was used for assessing substrate size. The frame was attached to a cable/winch assembly, while a separate cable from

[1] The stations for the dry ground elevation measurements were also measured using the hand held laser range finder.

Table 2
Study Site Flow (cfs)

Date	Release from Nimbus Dam
4/06/98	7374
4/13/98	7572
4/15/98	7532
4/20/98	7512
5/07/98	11175
5/15/98	11107
5/20/98 AM	9222
5/20/98 PM	8948
5/21/98	7617
7/13/98	4030
7/14/98	4023
7/15/98	4039
8/05/98	4030
9/09/98	2028
9/10/98	1040
11/12/98	2980
11/13/98	3024
11/23/98	3116
11/24/98	3114
12/01/98	3042

the remote cameras was connected to two TV monitors on the boat. The two monitors were used by the winch operator to distinguish changes in substrate size classes and determine the substrate size. Substrates were visually assessed (using a calibrated grid[2] on the monitor connected to the 90° camera for the deep water substrates) for the dominant particle size range (e.g., range of 2-4"). Table 3 gives the substrate codes and size classes used in this study. The substrate sizes were visually assessed from the headpin or tailpin to the location along the transect where the water became too deep for further visual assessment. At each change in substrate size class, the distance from the headpin or tailpin was measured using a hand held laser range finder. A buoy was placed at each location where visual assessment stopped. Assessment from that point was

Table 3
Substrate Descriptors and Codes

Code	Type	Particle Size (inches)
0.1	Sand/Silt	< 0.1
1	Small Gravel	0.1 - 1
1.2	Medium Gravel	1 - 2
1.3	Medium/Large Gravel	1 - 3
1.4	Medium/Large Gravel/Cobble	1 - 4
2.3	Large Gravel	2 - 3
2.4	Gravel/Cobble	2 - 4
3.4	Small Cobble	3 - 4
3.5	Small Cobble	3 - 5
3.6	Small/Medium Cobble	3 - 6
4.6	Medium Cobble	4 - 6
6.8	Large Cobble	6 - 8
8	Large Cobble	8 - 10
9	Bedrock	> 12
10	Large Cobble	10-12

[2] The grid was calibrated so that, when the camera frame was one foot off the bottom, the smallest grid corresponded to a two-inch substrate, the next largest grid corresponded to a four-inch substrate, etc.

continued across the transect by boat using the video camera assembly, with the distances where substrate size changed again measured with the hand held laser range finder. A buoy was again dropped at the location along the transect near the opposite shore where shallow water depth prevented further progress by boat. The substrate over the remaining distance from the buoy to the end of the transect was assessed using the same visual methods used on the opposite bank.

Hydraulic Model Construction and Calibration

All data were compiled and checked before entry into PHABSIM data decks. ASCII files of each ADCP run were produced using the Playback feature of the Transect program[3]. Each ASCII file was then imported into RHABSIM Version 2.0 to produce the bed elevations, average water column velocities, and stations (relative to the start of the ADCP run). RHABSIM was then used to output a second ASCII file containing this data. The second ASCII file was input into a QuattroPro spreadsheet and combined with the velocity, depth, and station data collected in shallow water. Typically, the last wet cell in shallow water had a measured velocity of 0 ft/s. These velocities were arbitrarily set to a low value (typically 0.01 ft/s) to get reasonable simulated velocities in cells that were dry at the velocity measurement flow. This practice is judged to be reasonable, since the measurement error of velocities is in the range of 0.01 ft/s. We defined a statistic (R) to provide a quality control check of the velocity measured by the ADCP at a given station n, where $R = Vel_n/(Vel_{n-1} + Vel_{n+1})/2$ at station n[4]. R was calculated for each velocity where Vel_n, Vel_{n-1} and Vel_{n+1} were all greater than 1 ft/s for each ADCP data set. Based on data collected using a Price AA velocity meter during our March 1996 Lower American River study, the acceptable range of R was set at 0.5-1.6. All verticals with R values less than 0.5 or greater than 1.6 were deleted from each ADCP data set[5]. Flows were calculated for each ADCP run, including the data collected in shallow water. The run for each cross section which had the flow closest to the actual flow, determined from the Nimbus Dam outflow gage reading (Table 2), was selected for use as a velocity set or to measure discharge. However, for split channels which had a small percentage of the total discharge, the split channel discharge was calculated by the average of the discharge from all of the ADCP runs. The ADCP runs selected for use are shown in Tables 4 and 5 and the ADCP settings used for the ADCP runs selected for use are shown in Table 6. As shown in Tables 4 and 5, the total discharge for the ADCP runs selected for use were usually within 5% and never more than 8% different from the actual flow.

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[3] The Transect program is the software used to receive, record and process data from the ADCP.

[4] n - 1 refers to the station immediately before station n and n + 1 refers to the station immediately after station n.

[5] We also deleted verticals where Vel_n was less than 1.00 ft/s and Vel_{n-1} and Vel_{n+1} were greater than 2.00 ft/s, and where Vel_n had one sign (negative or positive) and Vel_{n-1} and Vel_{n+1} had the opposite sign (when the absolute value of all three velocities were greater than 1.00 ft/s); these criteria were also based on the March 1996 dataset.

Table 4
ADCP Files Used for Velocity Sets

			File Name				
Site Name	XS	Date	Channel or Left Channel	Middle Channel	Right Channel	Measured Q	% Diff
Sailor Bar	1	11/13/98	MD8A240	MD8A237	MD8A231	2785	7.9%
Sailor Bar	2	11/13/98	MD4C136			2994	1.0%
Sailor Bar	3	11/13/98	MD4C139			3113	2.9%
Sailor Bar	4	11/13/98	MD8A219	MD8A227	MD8A230	3019	0.2%
Above Sunrise	1	11/24/98	MD8A275			3095	1%
Above Sunrise	2	11/24/98	MD8A273		MD4C154	3170	1.8%
Above Sunrise	5	11/24/98	MD4A066			2769	0%
Above Sunrise	6	11/24/98	MD8A271			3042	2%
Above Sunrise	7	11/13/98	MD8A243		D45D051	2973	1.7%
Sunrise	1	11/24/98	MD4C149			3076	1.22%
Sunrise	2	11/24/98	MD4C146			3200	2.76%
Sunrise	3	11/24/98	MD8A293			2967	4.72%
Sunrise	4	11/24/98	MD8A290		MD8A294	3092	0.7%
Sunrise	5	11/24/98	MD8A285			2966	4.75%
Sunrise	6	11/24/98	MD8A281			3107	0.22%
Sunrise	7	11/24/98	MD8A279			3110	0.13%
El Manto	1	12/01/98	MD8A296		MD8A300	3027	0.5%
El Manto	2	12/01/98	MD4C159			2887	5.1%
Rossmoor	1	11/23/98	MD8A268			3138	0.7%
Rossmoor	2	11/23/98	MD8A260		MD8A265	3129	0.4%
Rossmoor	3	11/23/98	MD8A258			3082	1.1%

Table 4 (continued)

Site Name	XS	Date	File Name: Channel or Left Channel	File Name: Middle Channel	File Name: Right Channel	Measured Q	% Diff
Rossmoor	4	11/23/98	MD8A256			3052	2.1%
Rossmoor	5	11/23/98	MD8A253		MD4C162	3127	0.4%
Rossmoor	6	11/23/98	MD8A249			2914	6.5%
Rossmoor	7	11/23/98	MD8A244			3146	1.0%

A table of substrate ranges/values was created to determine the substrate for each vertical/cell (e.g, if the substrate size class was 2-4" on a transect from station 50 to 70, all of the verticals with station values between 50 and 70 were given a substrate coding of 2.4). Dry bed elevation data in field notebooks were entered into the spreadsheet to extend the bed profile up the banks above the WSEL of the highest flow to be modeled. An ASCII file produced from the spreadsheet was run through the FLOMANN program (written by Andy Hamilton) to get the PHABSIM input file and then translated into RHABSIM files. RHABSIM was used rather than PHABSIM because the number of verticals per transect exceeded 100.

All of the measured WSELs were checked to make sure that water was not flowing uphill. A total of six to seven sets of WSELs at widely spaced flows were used. WSELs used for calibration were: 1) the average of the WSELs measured on each bank if these two values differed by no more than 0.10 feet; or 2) the WSEL identified during measurement as the most representative of the transect for cases where the WSELs on the two banks differed by more than 0.10 feet.

The WSELs used in the decks, along with the distances between transects, were then used to compute the slope to be used for each transect, as follows. For each transect, two slopes were computed at each measured flow, one using the difference in WSELs between the transect and the next transect downstream divided by the distance between the two, and the other in the same fashion using the next transect upstream. Each of these two slopes were averaged for all measured flows, and these two averages were then averaged again to determine the final slope used in the velocity simulation. For transects at either end of a study site (where either an adjacent upstream or downstream transect was absent), slopes were calculated minus the final averaging step.

A separate deck was constructed for the transects in each study site with the same flows; a separate deck was constructed for each split channel of transects with split channels.

Table 5
ADCP Files used for Discharges

			File Name				
Site Name	XS	Date	Channel or Left Channel	Middle Channel	Right Channel	Measured Q	% Diff
Sailor Bar	1	05/15/98	MD8A045			11336	2.1%
Sailor Bar	1	07/13/98	MD8A112	MD8A115		3996	0.8%
Sailor Bar	2	07/13/98	MD8A118			4031	0.0%
Sailor Bar	2	05/20/98	MD8A069			9363	2%
Sailor Bar	3	05/20/98	MD8A066			9258	0%
Sailor Bar	3	07/14/98	MD8A121			3820	5.0%
Sailor Bar	4	07/14/98	MD8A124	MD8A127	MD8A130	4003	0.5%
Sailor Bar	4	05/20/98	MD8A063			9351	1%
Above Sunrise	1	08/05/98	MD8A135			4050	0%
Above Sunrise	1	05/15/98	MD8A037			11386	3%
Above Sunrise	2	05/20/98	MD8A070			8816	1%
Above Sunrise	3	05/15/98	MD8A039			2194	0%
Above Sunrise	5	05/21/98	MD4E021			6313	1.5%
Above Sunrise	6	05/21/98	MD8A092			7652	0%
Above Sunrise	7	05/21/98	D45D028			7544	1%
Rossmoor	1	08/06/98	MD4C084			4105	1.5%
Rossmoor	1	05/15/98	MD8A030			11029	0.7%
Rossmoor	2	09/16/98	MD8A206		MD8A205	3867	4.8%

Table 6
CFG Files[5] Used for ADCP Data

CFG File	Mode	Depth Cell Size (cm)	Depth Cell Number	Max Bottom Track (ft)	Pings	WT	First Depth Cell (ft)	Blanking Dist. (cm)
MD8A	8	20	15	26	4	5	1.61	10
MD4A	4	20	15	26	8	5	1.84	10
MD4C	4	10	30	26	4	5	1.51	10
MD4E	4	20	30	26	4	5	1.84	10
D45D	8	20	30	26	4	5	1.94	20

The stage of zero flow (SZF), an important parameter used in calibrating the stage-discharge relationship, was determined for each transect and entered. In habitat types without backwater effects (e.g., riffles and runs), this value generally represents the lowest point in the streambed across a transect (thalweg elevation). However, if a transect directly upstream contains a lower thalweg elevation than the adjacent downstream transect, the SZF for the downstream transect applies to both. In some cases, data collected inbetween transects (not discussed in this report) showed a higher thalweg elevation than either transect; in these cases the higher thalweg elevation was used as the SZF. For Sunrise XS 1 Right Main Channel and Side Channel, we were able to survey in, at a low flow, the highest thalweg elevations downstream of these portions of XS 1; since these were higher than the thalweg elevations on these portions of XS 1, these elevations were used as the SZF. In one case (Sailor Bar XS 1 Right Channel), we were not able to measure a SZF because the SZF was the WSEL present downstream of the transect when the flow in Sailor Bar XS 1 Right Channel is zero. Since there was a flow in Sailor Bar XS 1 Right Channel at the lowest flow we observed (1040 cfs), we were unable to measure the WSEL downstream of the transect when the flow in Sailor Bar XS 1 Right Channel was zero; this is the only method that could be have been used to measure the SZF for this transect. For Sailor Bar XS 1 Right Channel, we computed a SZF using a feature of RHABSIM which calculates the SZF which best fits the measured WSELs and flows. Sailor Bar XS 1 Left/Main Channel was a combination of Sailor Bar XS 1 Left and Main Channels, and was used to simulate flows over 3,000 cfs. The bed elevations for Sailor Bar XS 1 Left/Main Channel were computed from depths measured at 7,561 cfs, resulting in a slightly different SZF than for Sailor Bar XS1 Left and Main Channels, which used bed elevations computed from depths measured at 3,024 cfs. The SZFs used for each transect are given in Appendix B.

[5] The first four characters of the ADCP runs designates which CDG file (containing the ADCP settings) was used for the runs.

Flow/flow regressions were performed for split-channel transects (Sailor Bar XS 1-4, Above Sunrise XS 1-5, Sunrise XS 1-2 and Rossmoor XS 1-2), using the split-channel flows measured in the lower-flow split channel (Table 5) and the corresponding total flows measured by the Nimbus Dam outflow gage. Flows for the higher-flow split channel were computed as the difference between the total flow and the lower-flow split channel flow. The flow/flow regressions used are given in Table 7. Calibration flows for transects with the entire river discharge (non-split channel transects) in the data decks (Appendix B) were the flows measured by the Nimbus Dam outflow gage. Calibration flows for split-channel transects were computed from the total discharge measured by the Nimbus Dam outflow gage and the appropriate regression equation in Table 7..

The first step in the calibration procedure was to determine the best approach for WSEL simulation. Initially, the *IFG4* hydraulic model (Milhous *et al.*, 1989) was run on each deck to compare predicted and measured WSELs. This model produces a stage-discharge relationship using a log-log linear rating curve calculated from at least three sets of measurements taken at different flows. Besides *IFG4*, two other hydraulic models are available in PHABSIM to predict stage-discharge relationships. These models are: 1) *MANSQ*, which operates under the assumption that the condition of the channel and the nature of the streambed controls WSELs; and 2) *WSP*, the water surface profile model, which calculates the energy loss between transects to determine WSELs. *MANSQ*, like *IFG4*, evaluates each transect independently. *WSP* must, by nature, link at least two adjacent transects. *IFG4,* the most versatile of these models, is considered to have worked well if the following standards are met: 1) the beta value (a measure of the change in channel roughness with changes in streamflow) is between 2.0 and 4.5; 2) the mean error in calculated versus given discharges is less than 10%; 3) there is no more than a 25% difference for any calculated versus given discharge; and 4) there is no more than a 0.1 foot difference between measured and simulated WSELs. *MANSQ* is considered to have worked well if standards 2-4 are met and if the beta value for *MANSQ* is within the range of 0 to 0.5. *WSP* is considered to have worked well if: 1) Manning's n values fall in the range of 0.4 to 0.7; 2) there is a negative log-log relationship between the roughness multiplier and flow; and 3) there is no more than a 0.1 foot difference between measured and simulated WSELs. In cases where initial calibration was unsuccessful using the above three models, the following aspects were examined to try to reach an acceptable calibration: 1) use of different sets of flows/WSELs; 2) changes in the regression equations for flow splits; 3) the presence of erroneous WSELs; 4) using WSELs measured on the left bank versus on the right bank; 5) the presence of a downstream hydraulic control that would raise the SZF; and 6) whether to model a transect as a split channel or not.

For a majority of the transects for at least a portion of the measured flows, *IFG4* met the above standards (Appendix B). *MANSQ* worked successfully for a number of transects, meeting standards 2-4 and having a *MANSQ* beta value within the range of 0 to 0.5 (Appendix B). *WSP* was used for the remaining transects, with the above standards for *WSP* being met, with the exception of having a positive log-log relationship between the roughness multiplier and flow for Sunrise XS 6 and Rossmoor XS 4 and 5. We viewed this as acceptable, since the measured

Table 7
Flow/Flow Regression Equations

Study Site	XS #	Flow Range	Regression Equation[6]
Sailor Bar	1	1000-3500	LCQ = 287 + 0.0035 x Q
Sailor Bar	1	1000-4000	RCQ = 10^(-2.396 + 1.487 x log (Q - 800))
Sailor Bar	1	4000-11000	RCQ = 10^(-3.641 + 1.777 x log (Q))
Sailor Bar	2	1000-4000	RCQ = 10^(-3.314 + 1.806 x log (Q - 350))
Sailor Bar	2	4000-11000	RCQ = -785 + 0.517 x Q
Sailor Bar	3	1000-4000	LCQ = -91+0.345 x Q
Sailor Bar	3	4000-11000	LCQ = -639 + 0.483 x Q
Sailor Bar	4	1000-4000	LCQ = 18 + 0.435 x Q
Sailor Bar	4	4000-11000	LCQ = 602 + 0.304 x Q
Above Sunrise	1	1000-11000	RCQ = -206 + 0.536 x Q
Above Sunrise	2	1000-11000	LCQ = 10^(0.133 + 0.773 x log(Q))
Above Sunrise	3-4	1000-4000	3/4Q = -152 + 0.188 x Q
Above Sunrise	3-4	4000-11000	3/4Q = -260 + 0.213 x Q
Sunrise	1	1000-2500	SCQ = 0
Sunrise	1	2500-11000	SCQ = 10^(-1.431 + 1.256 x log(Q - 2500))
Sunrise	1	1000-3100	RCQ = 0
Sunrise	1	3100-11000	RCQ = -635 + 0.205 x Q
Sunrise	2	1000-2900	SCQ = 0
Sunrise	2	2900-11000	SCQ = -614 + 0.215 x Q
Sunrise	2	1000-2000	RCQ = 0
Sunrise	2	2000-11000	RCQ = 10^(0.807 + 0.669 x log (Q - 2000))
Rossmoor	1	1000-3000	LCQ = -71 + 0.229 x Q
Rossmoor	1	3000-11000	LCQ = -371 + 0.357 x Q
Rossmoor	2	1000-4100	LCQ = 10^(-7.086 + 2.755 x log(Q))
Rossmoor	2	4100-11000	2LCQ = -103 + 0.718 x 1LCQ

[6] Q is the total river flow, LCQ is the left channel flow, etc.

WSELs showed that the water surface slope between Sunrise XS 5 and 6 and between Rossmoor XS 3 and 5 increased with flow for the range of flows modeled with *WSP*; this resulted in the roughness multiplier increasing with flow.

For most of the transects, we needed to simulate flows in two to three ranges (low, medium and high flows) with different sets of calibration WSELs (Appendix B) to meet the above standards. In most cases, we were able to have one calibration flow in common between each calibration set[7]; this improved the continuity in simulating WSELs when switching from one calibration set to the next calibration set.

We changed the regression equations for flow splits to improve the fit of the split-channel flows predicted by the regression equations to the measured split-channel flows for the following transects: Sailor Bar XS 1 RC and XS 2 RC, Sunrise XS 1 RMC and SC, and Rossmoor XS 1 LC and XS 2 LC; these changes improved the WSEL calibration for these transects.

We found three cases where there were erroneous WSELs: 1) Sailor Bar XS 1 MC at 2,028 cfs; 2) Above Sunrise XS 1 RC at 4,023 cfs; and 3)Rossmoor XS 1 LC and RC at 3,116 and 11,175 cfs. We concluded that the WSEL measured at Sailor Bar XS1 MC at 2,028 cfs was approximately 0.5 feet low because it was lower than the WSELs for XS 1 LC and RC, while at 1,040 cfs, 2,980 cfs and 4,030 cfs the WSEL for XS1 MC was higher than the WSELs for XS 1 LC and RC; as a result, we did not use the Sailor Bar XS1 MC WSEL at 2,028 cfs. We concluded that the WSEL measured at Above Sunrise XS 1 RC at 4,039 cfs was approximately 0.11 feet low, based on a similar comparison to the WSELs measured on XS1 LC, and on XS1 RC at other flows; as a result, we did not use the Above Sunrise XS 1 RC WSEL at 4,039 cfs. We concluded that the WSELs for Rossmoor XS 1 LC and RC measured at 3,116 cfs and 11,175 cfs had been reversed in the databook because at these two flows, the LC WSEL was less than the RC WSEL, while at the other four flows the LC WSEL was greater than the RC WSEL; as a result, we reversed the WSELs used for Rossmoor XS 1 LC and RC at 3,116 cfs and 11,175 cfs.

We changed the left bank versus right bank WSELs used for six cases: 1) Sailor Bar XS 1 L/MC at 7,374 cfs; 2) Sunrise XS 2 LMC at 2,980 cfs; 3) Sunrise XS 5 at all flows; 4) Sunrise XS 7 at all flows; 5) El Manto XS 1 at 4,039 cfs; and 6) Rossmoor XS 6 at 4,039, 7,532 and 11,175 cfs; these changes improved the calibrations for these transects. We had measured the WSEL for Sailor Bar XS 1 L/MC at 7,374 cfs only on the left bank, while the right bank was more representative of this channel; we added 0.10' to the left bank WSEL to estimate the right bank WSEL at this flow, based on the difference between right bank and left bank WSELs at other

[7] The only exceptions, as shown in Appendix B, were for Sailor Bar XS 2 RC (3000 to 4000 cfs), Above Sunrise XS 1 LC (3000 to 4000 cfs), Above Sunrise XS 2 LC (4000 to 7500 cfs), Above Sunrise XS 4 (2000 to 3000 cfs), Sunrise XS 1 LMC (3000 to 4000 cfs), Sunrise XS 2 LMC (2000 to 3000 cfs), Sunrise XS 5 (2000 to 3000 cfs), Rossmoor XS 1 LC (4000 to 7500 cfs) and Rossmoor XS 6 (3000 to 4000 cfs).

flows. For Sunrise XS 2 LMC at 2,980 cfs, we originally used a WSEL measured at the right edge of this channel; we changed to using the left bank WSEL at 2,980 cfs to be consistent with the left bank WSELs used at 4,039 and 7,512 cfs. For Sunrise XS 5, we originally used the average of the left bank and right bank WSELs at all flows; however, since we had only measured the right-bank WSEL at 2,890 cfs, we used the right bank WSELs at all flows to be consistent. For Sunrise XS 7, we previously used all left bank WSELs except for an average of left and right bank WSELs at 7,512 cfs; we switched to using all right bank WSELs to improve the calibration for this transect. For El Manto XS 1, we originally used the right bank WSEL at 4,039 cfs and the left bank WSELs at 7,532 and 11,175 cfs; we changed the WSEL used at 4,039 cfs to the left bank WSEL to be consistent with the WSELs used at the other two flows. For Rossmoor XS 6, we switched from using a mid-channel WSEL at 4,039 cfs and the average of left and right banks WSELs at 7,532 and 11,175 cfs to using all left bank WSELs at these three flows to get the *IFG4* beta value to be greater than 2.0.

We increased the SZF for Sunrise XS 1 RMC and XS 2 SC to improve the calibration for these transect, as follows. We set the SZF for Sunrise XS 1 RMC to the WSEL for this channel measured at 2,980 cfs since the flow-flow regression predicted that the flow for Sunrise XS 1 RMC was zero at a total flow of 2,980 cfs; by definition, the SZF is the WSEL when the flow is zero. We assumed that the SZF for Sunrise XS 2 SC was the WSEL for Sunrise XS 2 RMC at the total flow where the flow for Sunrise XS 2 SC is zero, based on the assumption that there would not be a water surface gradient from XS 2 SC to XS 2 RMC when the XS 2 SC flow was zero.

We decided to model Sailor Bar XS 3 and Above Sunrise XS 2 as non-split channels up to 3,000 cfs, since the left bank and right bank WSELs for these transect were within 0.10 feet at the calibration flows below 3,000 cfs. We modeled Sailor Bar XS 1 L/MC as a single split channel, rather than two split channels (LC and MC) for flows above 3,000 cfs because we had not measured a WSEL for Sailor Bar XS 1 MC at 7,374 cfs and because we were unable to model Sailor Bar XS 1 LC above 3,000 cfs. In addition, we used the WSELs simulated between 3,000 and 4000 cfs with Sailor Bar XS 1 MC for Sailor Bar XS 1 L/MC because we were unable to simulated Sailor Bar XS 1 L/MC below 4,000 cfs and because Sailor Bar XS 1 MC is most reprepentative of the WSEL of Sailor Bar XS 1 L/MC.

For those transects/flow ranges modeled with *IFG4*, the mean error and calculated-given discharge difference standard were met in all cases, and the measured-simulated WSEL difference standard was met in all cases except for Sailor Bar XS 1 LMC (4,000 - 11,000 cfs), Above Sunrise XS 1 RC (2000 - 7,500 cfs), and Sunrise XS 1 SC (Appendix B). For the above three transects, we still used *IFG4* because *MANSQ* gave much greater errors, *WSP* could not be used because they were the downstream-most transects in the site, and because all of the above six aspects used to improve calibration were unable to meet the measured-simulated WSEL difference standard; in addition, the difference between measured and simulated WSELs for all three transects was less than 0.20 feet. As shown in Appendix B, the beta coefficient was less than 2.0 for the following transects calibrated with *IFG4*: 1) Sailor Bar XS 1 LC; 2) Sailor Bar XS 2 LC; 3) Above Sunrise XS 1 LC (7,500 - 11,000 cfs); 4) Above Sunrise XS 2 RC (4,000 - 11,000 cfs); 5) Sunrise 1 RMC; 6) Sunrise 2 SC; 7) Sunrise XS 7 (1,000 - 3,000 cfs); 8) Rossmoor XS 2 RC (4,000 - 11,000 cfs); and 9) Rossmor XS 7 (4,000 - 11,000 cfs). In addition, the Velocity Adjustment Factor (VAF) for Sailor Bar XS 1 LC and 2 LC, Above Sunrise XS 1 RC, 2, and 2 RC, Above Sunrise XS 6 and 7, and El Manto XS 1 show a significant decrease with increasing flow (Appendix C). VAFs typically increase monotonically with increasing flows as higher flows produce higher water velocities. The model, in mass balancing, was obviously decreasing water velocities at high flows so that the known discharge would pass through the increased cross-sectional area. We concluded that both of these phenomena were caused in some cases by channel characteristics which form hydraulic controls at some flows but not at others (compound controls), thus affecting upstream water surface elevations. Specifically, at lower flows the channel at these transect controlled the water surface elevations, while at higher flows the water surface elevations were controlled by downstream hydraulic controls. For the remaining cases, consisting of at least some of the split-channel transects, the above phenomena were caused by a combination of downstream controls on water surface elevations and upstream controls on split-channel discharge. Sailor Bar XS 1 LC had the most extreme example of this phenomenon where the amount of discharge in XS 1 LC discharge changed very little with increasing total river flow due to upstream bed topography while the WSEL for XS 1 LC increased dramatically with increasing total river flow due to a downstream hydraulic control. We observed this phenomena in comparing the discharge measured in Sailor Bar XS 1 LC at 2,028 and 4,039 cfs; cells in the main portion of Sailor Bar XS 1 LC had higher velocities but lower depths at 2,028 cfs versus at 4,039 cfs, resulting in a very small difference in flow. Accordingly, the performance of *IFG4* for these transects was considered adequate despite the beta coefficient standard not being met. As shown in Appendix B, the only transect which had a beta coefficient greater than 4.5 was Rossmoor XS 2 LC (1,000 - 4,000 cfs); we attributed this to the flow dynamics associated with the split channel. Since the predicted WSELs were within 0.10 feet of the measured WSELs and since we did not extrapolate beyond the range of calibration flows, the performance of *IFG4* for this transect was considered adequate despite the beta coefficient standard not being met.

WSELs were simulated at flows from 1,000 to 3,000 cfs by 200 cfs increments, from 3,000 cfs to 9,800 cfs by 400 cfs increments and from 9,800 to 11,000 cfs by 600 cfs increments. For those transects where there was not a common calibration flow between two calibration sets (Footnote 7), the lower calibration set was used to simulate WSELs up to the lowest calibration flow in the upper calibration set, while the upper calibration set was used to simulate WSELs starting with the highest calibration flow in the lower calibration set. The point at which the WSELs from the two calibration sets crossed was selected as the point to switch from the lower to the higher calibration set. Where the WSELs from the two calibration sets did not cross, the WSEL at the simulation flow where the WSELs from the two calibration set were closest was calculated as the average of the WSELs from the two calibration sets; this was done for Sailor Bar XS 2 RC at 3,400 cfs and for Above Sunrise 1 LC at 3,800 cfs. The final step in simulating WSELs was to check whether water was going uphill at any of the simulated WSELs. This occurred at Sailor Bar XS 4 RC at 6,000-7,000 cfs, at Above Sunrise XS 2 LC at 6,200 cfs and at Above Sunrise XS 6 at 1,200 cfs. It appears that there is a very low WSEL gradient at these transects and flow ranges; accordingly, we used *WSP* for these transects by setting the simulated WSELs for the transects equal to the WSEL at the next-most downstream transect (Appendix B).

Velocity calibration is the final step in the preparation of the hydraulic models for use in habitat simulation. *IFG4* calculates Manning's n values for each cell from the slope (S) of the transect and the depth (d) and velocity (V) measured at the velocity-set flow, using the following formula:

$$n = 1.486\,(S^{.5})(d^{.667})/V$$

IFG4 then uses the Manning's n value for each cell to simulate the velocity in each cell at each simulation flow.

An *IFG4* deck was prepared for each study site and for each split channel, with the WSELs simulated for each of the simulation flows entered into the decks. Except for Sunrise XS 1 SC and RMC, the decks used the velocity set collected at around 3,000 cfs. Sunrise XS 1 SC and RMC used velocity sets collected at 4,039 cfs because the low flows present in these transects at 3,000 cfs would have resulted in inaccurate velocity simulations. The following higher-flow velocity sets were used to simulate velocities for flows between 4,000 and 11,000 cfs for the following transects, since our initial velocity calibration indicated that the velocity simulation failed at higher flows, based on a maximum velocity at 11,000 cfs exceeding 11-12 ft/s: 1) Sailor Bar XS 1 RC and L/MC (11,107 cfs); 2) Sailor Bar XS 4 RC (9,222 cfs); 3) Above Sunrise XS 2 RC (7,408 cfs); and 4) Above Sunrise XS 6 and 7 (7,617 cfs). Modifications were made to the decks for two other transects to simulate higher flows: 1) for El Manto XS 2, the velocity in the last left-bank cell was deleted to simulate flows from 4,000 to 11,000 cfs to more accurately simulate velocities in dry cells; and 2) for Sunrise XS 2, the back portion of the channel, which only has flow in it at higher flows due to upstream bed topography, was only used to simulate flows above 6,000 cfs, while this portion of the transect was deleted to simulate flows less than 6,000 cfs.

VAFs were examined for all of the simulated flows, and velocity statistics were computed for the lowest and highest flows and the flow for which there was a velocity set (Appendix C). As discussed above, the only transects that deviated significantly from the expected pattern of VAFs were Sailor Bar XS 1 LC and 2 LC, Above Sunrise XS 1 RC, 2, and 2 RC, Above Sunrise XS 6 and 7, and El Manto XS 1. We conclude that the deviations were due to compound controls or split channel dynamics, and thus the pattern of VAFs for all transects was acceptable. The abrupt changes in VAFs from 3,800 to 4,600 cfs for Sailor Bar XS 1 RC and 4 RC and Above Sunrise XS 2 RC, 6 and 7 were caused by switching from the low-flow velocity set to the high-flow velocity set, and are thus acceptable. The abrupt drop in VAF from 5,400 to 6,200 cfs for Sunrise XS 2 SC was caused by the abrupt increase in cross-sectional area associated with the start of flow in the back portion of this transect as flows get above 6,000 cfs, and is thus acceptable. In addition, with the exception of Sailor Bar XS 1 RC and Rossmoor XS 2 LC at

1,000 cfs, the VAF values were within the acceptable range of 0.2 to 5.0 (Appendix C). We concluded that the low VAFs for Sailor Bar XS 1 RC and Rossmoor XS 2 LC at 1,000 cfs (0.05 and 0.14) were due to very strong backwater effects; specifically, when there is a small drop in WSEL relative to the depth, the predicted velocities at low flows have to be significantly reduced to match the calculated flow. This, we conclude that the low VAF values for Sailor Bar XS 1 RC and Rossmoor XS 2 LC are acceptable. The velocity statistics (Appendix C) were generally acceptable; the larger deviations between measured and predicted velocities (Above Sunrise XS 3 and 4) were due to errors associated with the flow-flow regression equations for these transects.

Habitat Suitability Curves

Habitat suitability curves (HSC or HSI Curves) are used within PHABSIM to translate hydraulic and structural elements of rivers into indices of habitat quality (Bovee 1994). Two sets of HSC were used in this study, one for fall-run chinook salmon spawning and one for steelhead trout spawning (Figures 1 through 3, Appendix D). The salmon criteria (U.S. Fish and Wildlife Service 1997) were based on data we collected on fall-run chinook salmon redds in the Lower American River, while the steelhead criteria (U.S. Fish and Wildlife Service 1996) were based on depth and velocity data collected by CDFG on steelhead redds in the Lower American River and substrate data collected on steelhead redds in the Trinity River.

The initial steelhead HSC showed suitability rapidly decreasing for depths greater than 1.5 feet. This effect was likely due to the low availability of deeper water in the Lower American River with suitable velocities and substrates rather than a selection by steelhead of only shallow depths for spawning. The following method was used to correct the depth criteria for the low availability of deeper water with suitable velocities and substrates[8]. Based on the distribution of velocity and substrate redd data, we concluded that suitable velocities were between 0.3 and 1.99 ft/s, while suitable substrates were 2-3 inches in diameter (i.e., substrate code 2.3). A series of HSC sets were constructed where: 1) each set held velocity and substrate HSI values at 1.0 for the velocity and substrate range noted above with all other velocities and substrates assigned a value of 0.0; and 2) each set assigned a different 0.5-foot depth increment an HSI value of 1.0 for depths between 1.5 and 4.5 feet deep, with the other 0.5-foot increments and depths less than 1.5 foot and greater than 4.5 feet given a value of 0.0 (e.g., 1.5-2' depth HSI value equal 1.0, <1.5' and >2' depths HSI value equals 0.0 for set #1, etc.). Thus, six sets of HSC were constructed differing only in the suitabilities assigned for optimum depth ranges. Each HSC set was run through the RHABSIM program using the output of the calibrated hydraulic decks for the three spawning habitat modeling sites from our March 1996 study[9] at which CDFG collected HSC data, with the resulting habitat output combined in a spreadsheet to determine the available river

[8] See Gard 1998 for more information about this method.

[9] The decks were run at the average Lower American River flow during CDFG's collection of steelhead spawning data (927 cfs).

Figure 1

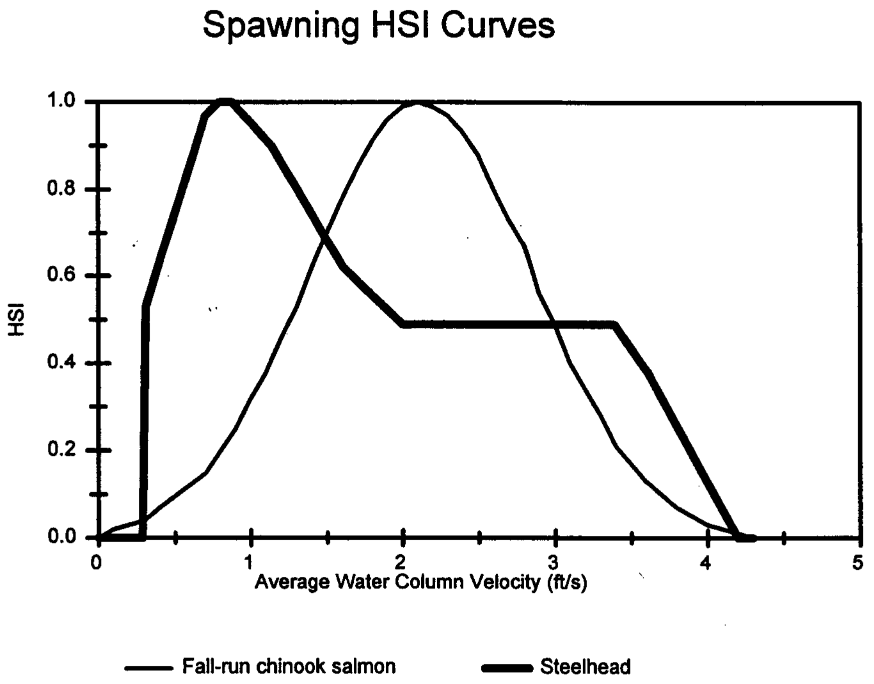


Figure 2

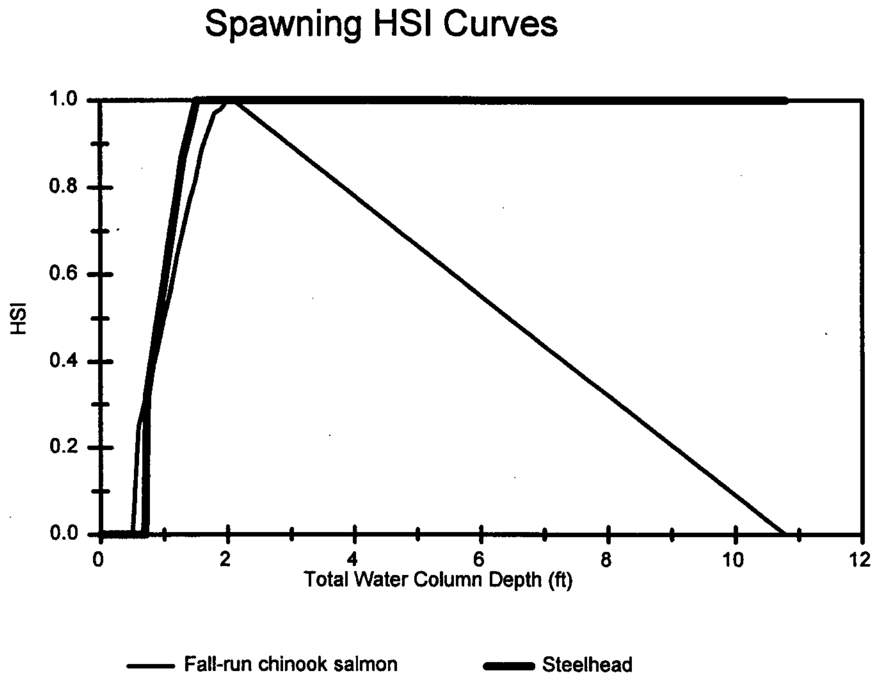
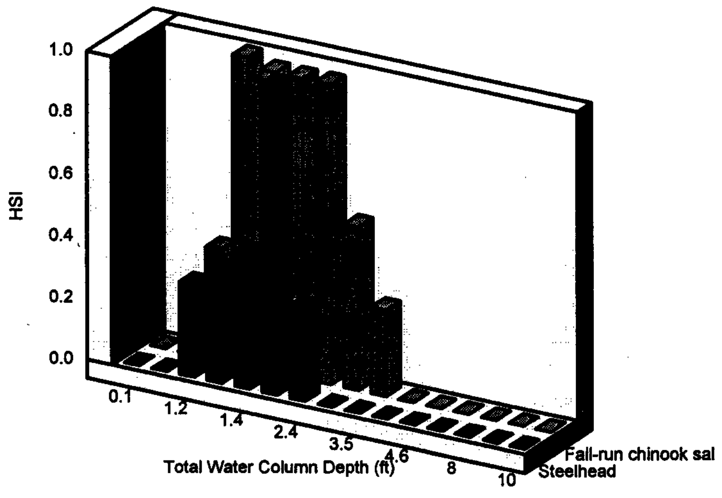


Figure 3

Spawning HSI Curves



area with suitable velocities and substrates for the 0.5-foot depth increments from 1.5 to 4.5 feet. The redd data collected by CDFG were used to determine the number of redds in each of the above depth increments to assess use. Relative availability and use were then computed by dividing the availability and use for each depth increment by the largest availability or use, thus scaling both measures to have a maximum value of 1.0. Linear regressions of relative availability and use versus the midpoint of the depth increments (i.e., 1.75' for 1.5-2' depth increment) were used to remove noise from the data and produce linearized values of relative availability and use at the midpoints of the depth increments. The results of the regressions showed that availability dropped quicker with increasing depth than use, indicating that use is entirely controlled by availability. As a result, the original HSC depth curve was modified to have a suitability of 1.0 for all depths greater than 1.51 feet (the peak of the original HSC curve).

Habitat Simulation

The final step in the process was to simulate available habitat for each transect. An input file was created containing the digitized HSC in Appendix D. The RHABSIM version of the HABTAE program was used to compute WUA for each transect over the desired range of flows (1,000 cfs to 3,000 cfs by 200 cfs increments, 3,000 cfs to 9,800 cfs by 400 cfs increments, and 9,800 cfs to 11,000 cfs by 600 cfs increments). We switched from using Sailor Bar XS 1 LC and MC, Sailor Bar XS 3 and Above Sunrise XS 2 to, respectively, Sailor Bar XS 1 L/MC, Sailor Bar XS 3 RC and LC, and Above Sunrise XS 2 RC and LC, at 3,000 cfs. We switched from the low flow deck to the high flow deck for Sailor Bar XS 1 RC and 4 RC, Above Sunrise XS 2 RC, 6 and 7, and El Manto at 4,000 cfs. We switched from the low flow to the high flow deck for Sunrise XS 2 SC at 6,000 cfs. The WUA values calculated for each transect and criteria set are contained in Appendix E.

The WUA values for each transect for steelhead trout from Appendix E of U.S. Fish and Wildlife Servive 1996 and the WUA values for each transect for chinook salmon from Appendix B of U.S. Fish and Wildlife Service 1997 were entered into a spreadsheet and multiplied by the river length for each transect in Table 8 to generate the WUA (square feet) for each transect at each simulation flow. The resulting WUA for the transects were summed to generate the total WUA for fall-run chinook salmon and steelhead trout spawning in the Lower American River before the January 1997 flood.

The WUA values for each transect from Appendix E of this report were entered into a spreadsheet and multiplied by the river length for each transect in Table 9 to generate the WUA (square feet) for each transect at each simulation flow. The resulting WUA for the transects were summed to generate the total WUA for fall-run chinook salmon and steelhead trout spawning in the Lower American River after the January 1997 flood.

Table 8
River Lengths Represented by Each Transect in March 1996 Study

Site	XS	Length
Sailor Bar	1 LC	915
Sailor Bar	1 RC	693
Sailor Bar	2	576
Above Sunrise 14	1	78
Above Sunrise 14	2	522
Above Sunrise 16	1	219.3
Above Sunrise 16	2	290.7
Above Sunrise 23	1	177.6
Above Sunrise 23	2	62.4
At Sunrise 26	1	223.2
At Sunrise 26	2	136.8
Below Sunrise 29	1	243.6
Below Sunrise 29	2	596.4
Below Sunrise 30	1	561.6
Below Sunrise 30	2	158.4
El Manto	1	480
El Manto	2	480
Rossmoor 2	1	358.8
Rossmoor 2	2	421.2
Rossmoor 1	1	372.6
Rossmoor 1	2	167.4

Table 9
River Lengths Represented by Transects in This Study

Site	XS	Length
Sailor Bar	1 LC	176
Sailor Bar	1 RC	796
Sailor Bar	1 MC	596
Sailor Bar	1 L\MC	596
Sailor Bar	2 LC	286
Sailor Bar	2 RC	303
Sailor Bar	3	524
Sailor Bar	3 LC	453
Sailor Bar	3 RC	595
Sailor Bar	4 LC	345
Sailor Bar	4 RC	267
Above Sunrise	1 LC	211
Above Sunrise	1 RC	209
Above Sunrise	2	346.5
Above Sunrise	2 LC	365
Above Sunrise	2 RC	328
Above Sunrise	3	611
Above Sunrise	4	284
Above Sunrise	5	393
Above Sunrise	6	1027
Above Sunrise	7	264
Sunrise	1 LMC	260
Sunrise	1 RMC	209
Sunrise	1 SC	176
Sunrise	2 LMC	322
Sunrise	2 RMC	353
Sunrise	2 SC	352
Sunrise	3	470
Sunrise	4	808
Sunrise	5	1020
Sunrise	6	269
Sunrise	7	168
El Manto	1	555
El Manto	2	532
Rossmoor	1 LC	286
Rossmoor	1 RC	220
Rossmoor	2 LC	608
Rossmoor	2 RC	334
Rossmoor	3	1415
Rossmoor	4	513
Rossmoor	5	489
Rossmoor	6	159
Rossmoor	7	341

RESULTS

The flow-habitat relationships for fall-run chinook salmon and steelhead trout spawning in the Lower American River before and after the January 1997 flood are shown in Figures 4 and 5. The results indicate that the January 1997 flood did not significantly change the flow-habitat relationship for fall-run chinook salmon and steelhead trout spawning in the Lower American River. The most significant difference between the pre-1997 and post-1997 flow-habitat relationships was the rise in steelhead spawning WUA from 3,800 to 4,200 cfs for the post-1997 flow-habitat relationship; this was caused by switching from the low-flow to the high-flow deck for Above Sunrise XS 6 and 7 at 4,000 cfs. The March 1996 study used only velocity sets collected at 2,250 to 3,000 cfs, while this study also used velocity sets collected at higher flows (7,500 to 11,000 cfs). The decreased rate of fall of fall-run chinook salmon spawning habitat above 4,000 cfs in this study, versus the March 1996 study is also likely due to the use of higher-flow velocity sets. The difference in WUA at a given flow with a different velocity set reflects a drawback of PHABSIM that it is unable to fully account for changes in flow distribution across a channel with changes in flow; the use of a two-dimensional hydraulic and habitat model would result in a more accurate modeling of velocities over a range of flows because it takes into account upstream and downstream bed topography and bed roughness, and explicitly uses mechanistic processes (conservation of mass and momentum), rather than Manning's n and VAF.

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Figure 4

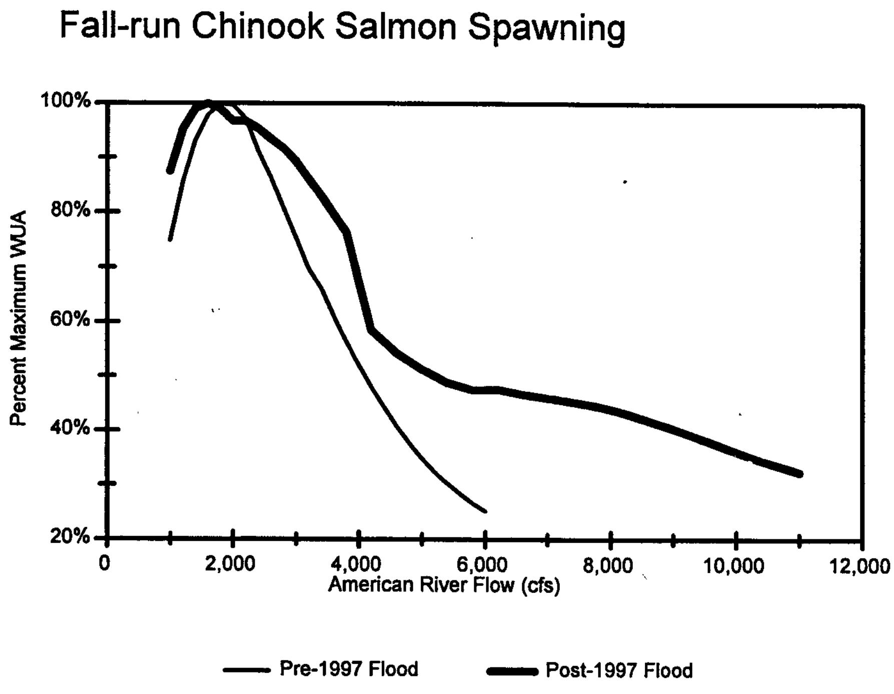
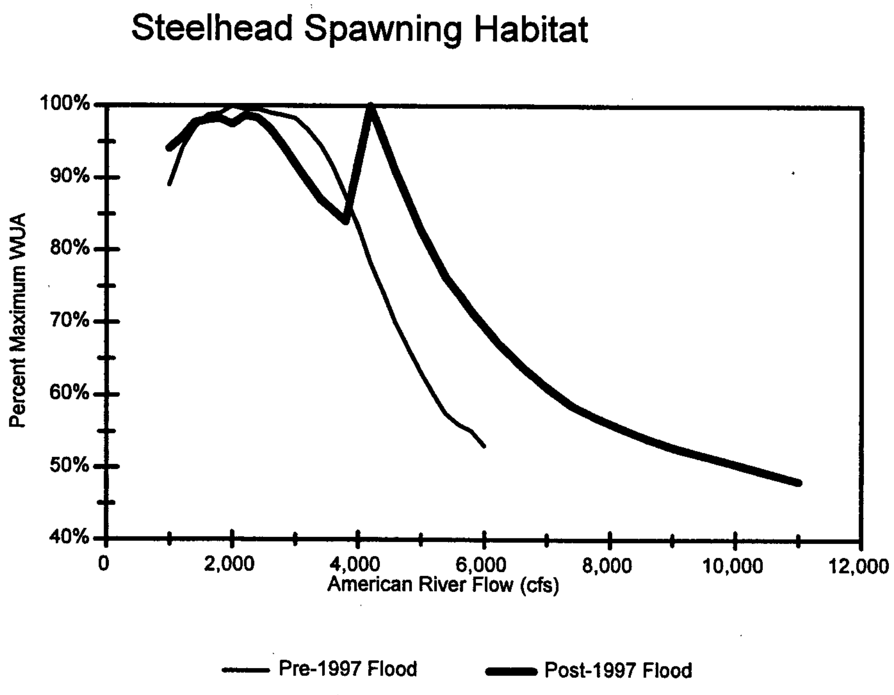
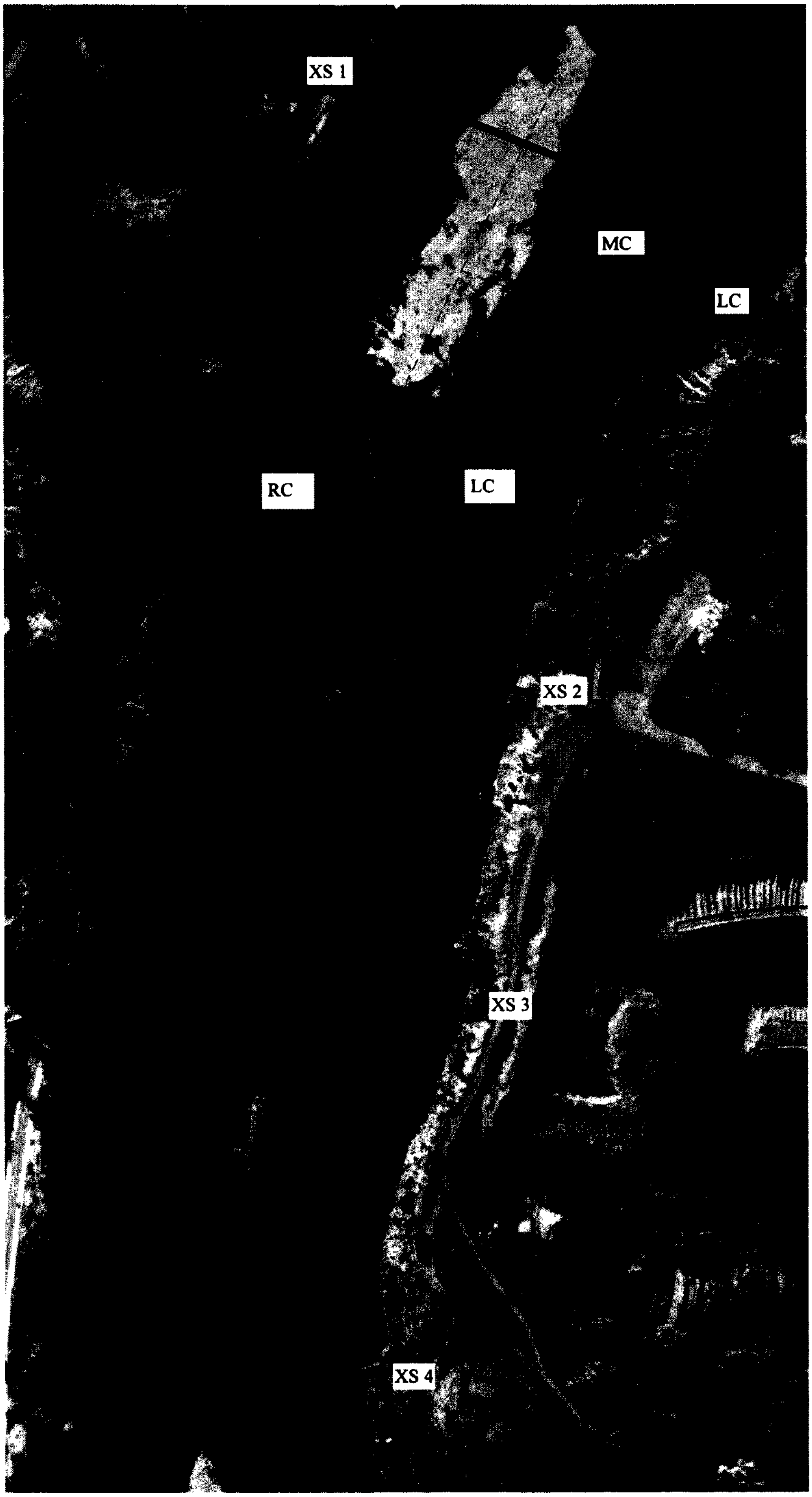


Figure 5

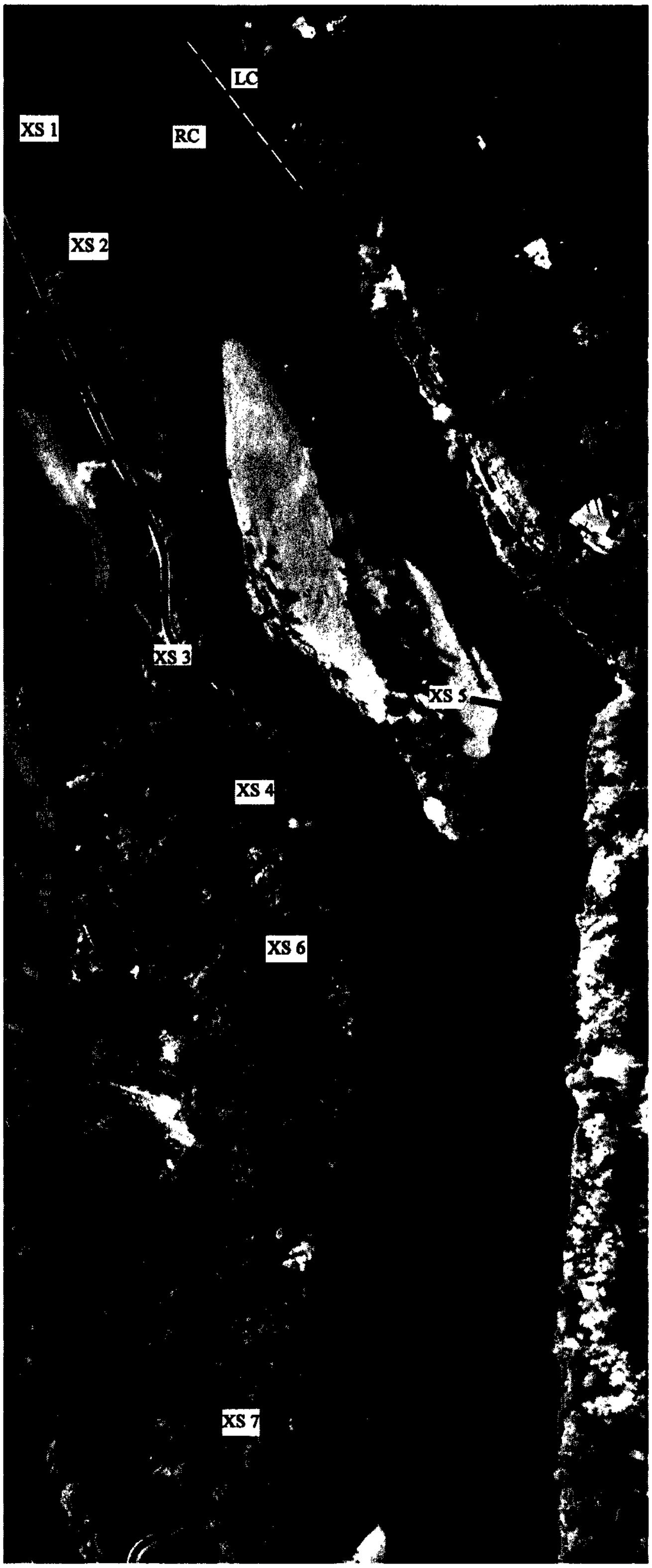


APPENDIX A
STUDY SITE AND TRANSECT LOCATIONS

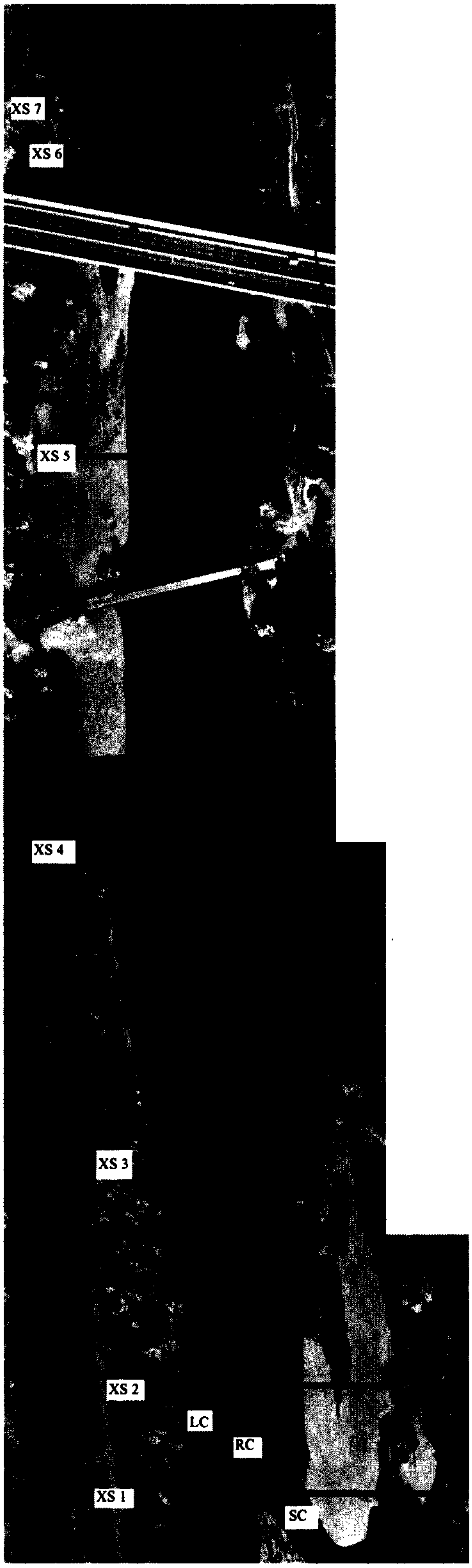
Sailor Bar Study Site



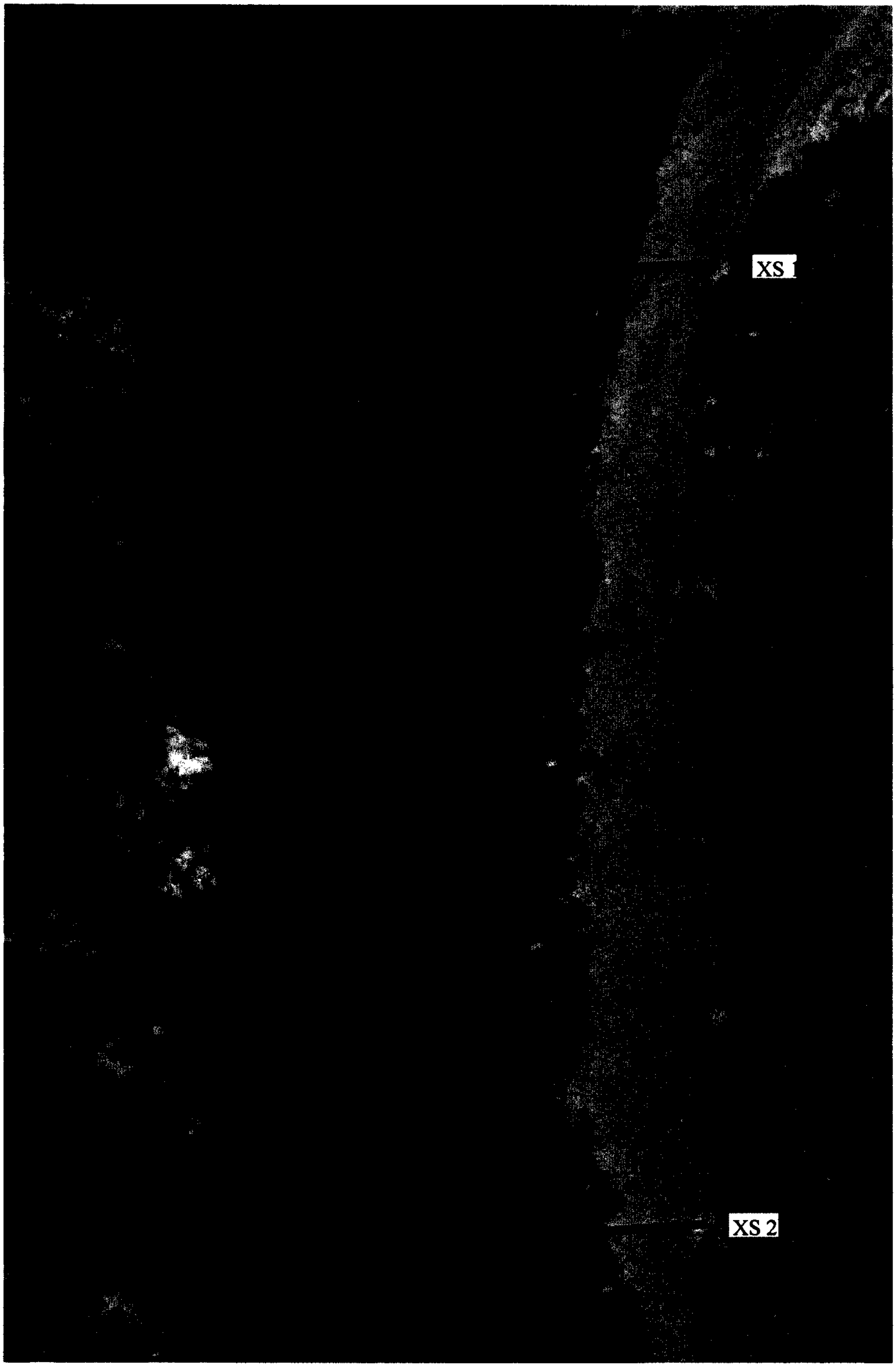
Above Sunrise Study Site



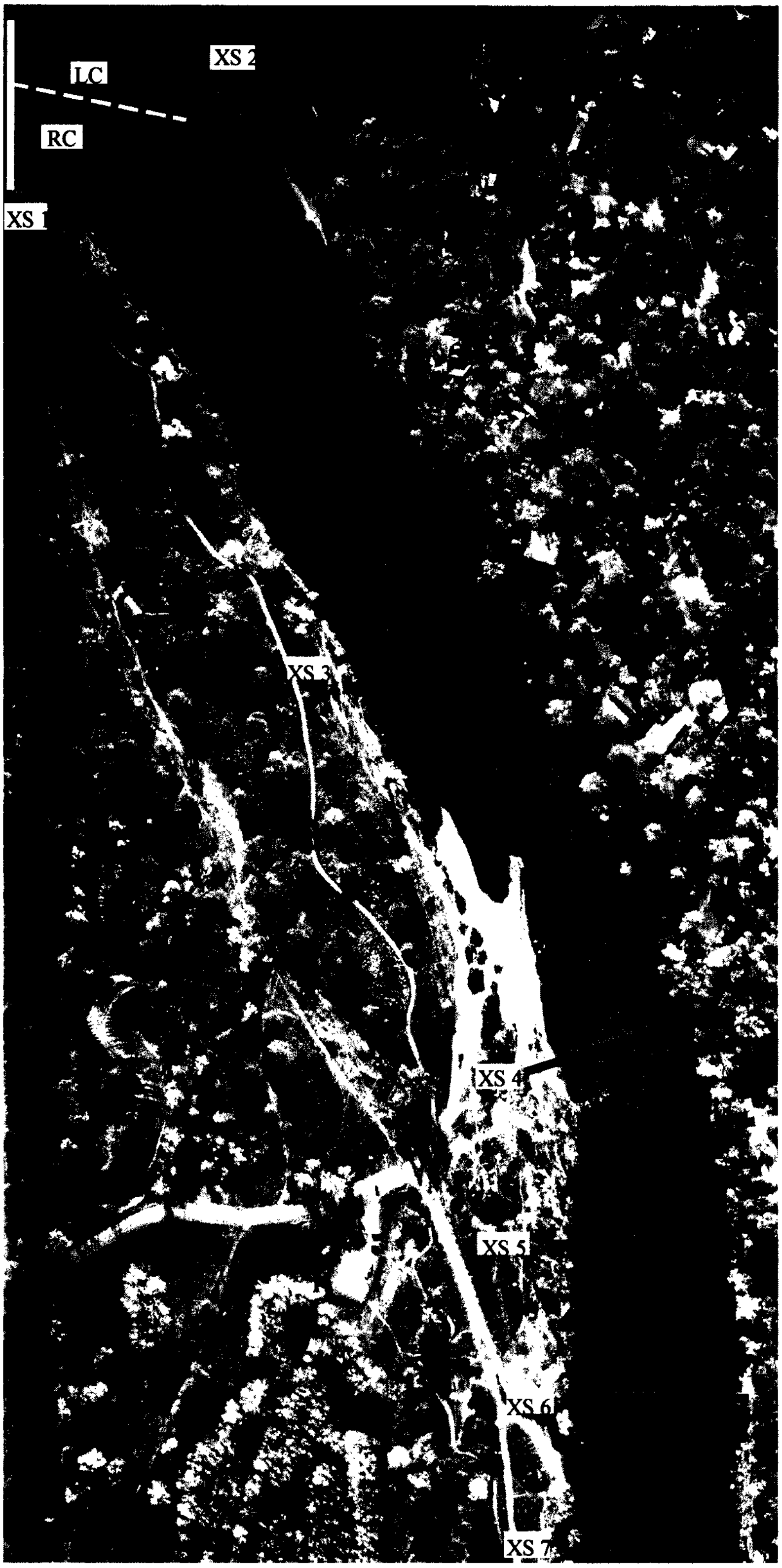
Sunrise Study Site



El Manto Study Site



Rossmoor Study Site



APPENDIX B
WSEL CALIBRATION

Stage of Zero Flow Values

Study Site	XS #	SZF
Sailor	1 RC	77.5
Sailor	1 LC	74.3
Sailor	1 LMC	74.5
Sailor	1 MC	74.4
Sailor	2 RC	78.9
Sailor	2 LC	78.4
Sailor	3	78.5
Sailor	3 RC	78.9
Sailor	3 LC	79.7
Sailor	4 RC	78.9
Sailor	4 LC	79.7
Above Sunrise	1 RC	79.5
Above Sunrise	1 LC	76.7
Above Sunrise	2	78.1
Above Sunrise	2 RC	80.4
Above Sunrise	2 LC	78.1
Above Sunrise	3	83.0
Above Sunrise	4	84.8
Above Sunrise	5	78.1
Above Sunrise	6	82.8
Above Sunrise	7	82.8
Sunrise	1 RMC	94.2

Study Site	XS #	SZF
Sunrise	1 LMC	84.5
Sunrise	1 SC	91.4
Sunrise	2 RMC	91.9
Sunrise	2 LMC	84.5
Sunrise	2 SC	94.2
Sunrise	3	88.3
Sunrise	4	90.1
Sunrise	5	90.1
Sunrise	6	91.0
Sunrise	7	92.1
El Manto	1	87.4
El Manto	2	91.0
Rossmoor	1 RC	86.2
Rossmoor	1 LC	87.3
Rossmoor	2 RC	86.8
Rossmoor	2 LC	87.3
Rossmoor	3	86.8
Rossmoor	4	86.9
Rossmoor	5	87.7
Rossmoor	6	88.7
Rossmoor	7	88.7

Calibration Methods and Parameters Used

Study Site	XS #	Flow Range	Calibration Flows	Method	Parameters
Sailor	1 RC	1,000-4,000	1040, 2028, 2980, 4030	IFG4	---
Sailor	1 RC	4,000-11,000	4030, 7374, 11175	IFG4	---
Sailor	1 LC	1,000-3,000	1040, 2028, 2980	IFG4	---
Sailor	1 LMC	4,000-11,000	4030, 7374, 11107	IFG4	---
Sailor	1 MC	1,000-4,000	1040, 2980, 4030	MANSQ	β = 0.385, CALQ = 1040
Sailor	2 RC	1,000-3,400	1040, 2028, 2980	MANSQ	β = 0.36, CALQ = 1040
Sailor	2 RC	3,400-7,000	4030, 7374	MANSQ	β = 0.405, CALQ = 4030
Sailor	2 RC	7,000-11,000	7374, 9222, 11175	IFG4	---
Sailor	2 LC	1,000-7,000	2028, 2980, 4030, 7374	IFG4	---
Sailor	2 LC	7,000-11,000	7374, 9222, 11175	IFG4	---
Sailor	3	1,000-3,000	1040, 2028, 2980	IFG4	---
Sailor	3 RC	3,000-7,000	2980, 4030, 7374	IFG4	---
Sailor	3 RC	7,000-11,000	7374, 9222, 11175	MANSQ	β = 0.2, CALQ = 7374
Sailor	3 LC	3,000-7,000	2980, 4030, 7374	IFG4	---
Sailor	3 LC	7,000-11,000	7374, 9222, 11175	MANSQ	β = 0.0, CALQ = 11175
Sailor	4 RC	1,000-3,000	1040, 2028, 2980	IFG4	---
Sailor	4 RC	3,000-6,000	2980, 4030, 7374	IFG4	---
Sailor	4 RC	6,000-7,000	7374	WSP	4 RC WSEL = 3 RC WSEL
Sailor	4 RC	7,000-11,000	7374, 9222, 11175	IFG4	---
Sailor	4 LC	1,000-3,000	1040, 2028, 2980	IFG4	---
Sailor	4 LC	3,000-7,000	2980, 4030, 7374	IFG4	---
Sailor	4 LC	7,000-11,000	7374, 9222, 11175	MANSQ	β = 0.0, CALQ = 9222

Study Site	XS #	Flow Range	Calibration Flows	Method	Parameters
Above Sunrise	1 RC	1,000-7,500	2028, 2980, 7512	IFG4	---
Above Sunrise	1 RC	7,500-11,000	7512, 8948, 11175	MANSQ	β = 0.00, CALQ = 8948
Above Sunrise	1 LC	1,000-3,800	2028, 2980	MANSQ	β = 0.00, CALQ = 2980
Above Sunrise	1 LC	3,800-11,000	4023, 7512, 8948, 11175	IFG4	---
Above Sunrise	2	1,000-3,000	1040, 2028, 2980	IFG4	---
Above Sunrise	2 RC	3,400-4,000	2980, 4023	MANSQ	β = 0.25, CALQ = 2980
Above Sunrise	2 RC	4,000-11,000	4023, 7512, 8948, 11175	IFG4	---
Above Sunrise	2 LC	3,400-5,800	2028, 2980, 4023	IFG4	---
Above Sunrise	2 LC	6,200	7512	WSP	XS2 LC WSEL = XS1 LC WSEL
Above Sunrise	2 LC	6,800-11,000	7512, 8948, 11175	IFG4	---
Above Sunrise	3	1,000-3,000	1040, 2028, 2980	IFG4	---
Above Sunrise	3	3,400-11,000	2980, 4023, 7512, 8948, 11175	IFG4	---
Above Sunrise	4	1,000-2,500	1040, 2028	MANSQ	β = 0.5, CALQ = 1040
Above Sunrise	4	2,500-11,000	2980, 4023, 7512, 11175	IFG4	---
Above Sunrise	5	1,000-4,000	1040, 2028, 2980, 4023	IFG4	---
Above Sunrise	5	4,000-11,000	4023, 7617, 11175	IFG4	---
Above Sunrise	6	1,000, 1400-4,000	1040, 2028, 2980, 4023	IFG4	---
Above Sunrise	6	1,200	1040	WSP	XS6 WSEL = XS4 WSEL
Above Sunrise	6	4,000-11,000	4023, 7512, 11175	IFG4	---
Above Sunrise	7	1,000-4,000	1040, 2028, 2980, 4023	IFG4	---
Above Sunrise	7	4,000-11,000	4023, 7512, 11175	IFG4	---

Study Site	XS #	Flow Range	Calibration Flows	Method	Parameters
Sunrise	1 RMC	3,400-11,000	4039, 7512, 11175	IFG4	---
Sunrise	1 LMC	1,000-3,000	1040, 2028, 2980	IFG4	---
Sunrise	1 LMC	3,400-11,000	4039, 7512, 11175	IFG4	---
Sunrise	1 SC	2,600-4,000	2980, 4039	MANSQ	$\beta = 0.5$, CALQ = 2980
Sunrise	1 SC	4,000-11,000	4039, 7512, 11175	IFG4	---
Sunrise	2 RMC	2,200-4,000	2028, 2980, 4039	IFG4	---
Sunrise	2 RMC	4,000-11,000	4039, 7512, 11175	IFG4	---
Sunrise	2 LMC	1,000-2,000	1040, 2028	MANSQ	$\beta = 0.37$, CALQ = 1040
Sunrise	2 LMC	2,200-11,000	2980, 4039, 7512	IFG4	---
Sunrise	2 SC	3,000-11,000	2980, 7512, 11175	IFG4	---
Sunrise	3	1,000-2,800	1040, 2028, 2980	IFG4	---
Sunrise	3	3,000-11,000	2980, 4039, 7512, 11175	IFG4	---
Sunrise	4	1,000-2,800	1040, 2028, 2980	IFG4	---
Sunrise	4	3,000-11,000	2980, 4039, 7512, 11175	IFG4	---
Sunrise	5	1,000-2,000	1040, 2028	MANSQ	$\beta = 0.43$, CALQ = 1040
Sunrise	5	2,200-11,000	2980, 4039, 7512, 11175	IFG4	---
Sunrise	6	1,000-2,800	1040, 2028, 2980	WSP	XS 5-6 n = 0.04, 1040 RM = 0.68, 2028 RM = 0.91, 2980 RM = 1.07
Sunrise	6	3,000-11,000	2980, 4039, 7512, 11175	IFG4	---
Sunrise	7	1,000-3,000	1040, 2028, 2980	IFG4	---
Sunrise	7	3,400-11,000	2980, 4039, 7512, 11175	MANSQ	$\beta = 0.02$, CALQ = 2980

Study Site	XS #	Flow Range	Calibration Flows	Method	Parameters
El Manto	1	1,000-4,000	1040, 2028, 3042, 4039	MANSQ	β = 0.45, CALQ = 3042
El Manto	1	4,000-11,000	4039, 7532 , 11175	IFG4	---
El Manto	2	1,000-4,000	1040, 2028, 3042, 4039	IFG4	---
El Manto	2	4,000-11,000	4039, 7532, 11175	WSP	XS 1-2 n = 0.04, 4039 RM = 0.958, 7532 RM = 0.952, 11175 RM = 0.948
Rossmoor	1 RC	1,000-4,000	1040, 2028, 3116, 4039	IFG4	---
Rossmoor	1 RC	4,000-11,000	4039, 7532, 11175	MANSQ	β = 0.03, CALQ = 11175
Rossmoor	1 LC	1,000-4,000	1040, 2028, 3116, 4039	IFG4	---
Rossmoor	1 LC	4,000-11,000	7532, 11175	MANSQ	β = 0.22, CALQ = 7532
Rossmoor	2 RC	1,000-7,500	1040, 2028, 3116, 4039, 7532	IFG4	---
Rossmoor	2 RC	7,500-11,000	4039, 7532, 11175	IFG4	---
Rossmoor	2 LC	1,000-4,000	1040, 2028, 3116, 4039	IFG4	---
Rossmoor	2 LC	4,000-11,000	4039, 7532, 11175	IFG4	---
Rossmoor	3	1,000-4,000	1040, 2028, 3116, 4039	IFG4	---
Rossmoor	3	4,000-11,000	4039, 7532, 11175	IFG4	---
Rossmoor	4	1,000-7,500	1040, 2028, 3116, 4039, 7532	IFG4	---
Rossmoor	4	7,500-11,000	7532, 11175	WSP	XS 3 n = 0.04, XS 4 n = 0.065, 7532 RM = 0.555, 11175 RM = 0.665
Rossmoor	5	1,000-7,500	1040, 2028, 3116, 4039, 7532	IFG4	---
Rossmoor	5	7,500-11,000	7532, 11175	WSP	XS 5 n = 0.04, 7532 RM = 0.555, 11175 RM = 0.665
Rossmoor	6	1,000-3,000	1040, 2028, 3116	IFG4	---
Rossmoor	6	3,400-11,000	4039, 7532, 11175	IFG4	---
Rossmoor	7	1,000-4,000	1040, 2028, 3116, 4039	IFG4	---
Rossmoor	7	4,000-11,000	4039, 7532, 11175	IFG4	---

Sailor Bar Site

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	2980 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	2980 cfs
1 LC	0.08	0.03	0.0	0.0	0.0	0.01	0.03	0.02
2 RC	---	8.07	0.0	17.6	6.6	None	0.10	0.06
3	3.37	5.08	3.6	8.0	4.0	0.03	0.08	0.05
4 RC	3.28	3.50	2.3	5.4	2.9	0.02	0.06	0.04
4 LC	2.27	0.56	0.3	0.9	0.5	None	0.01	0.01

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	2980 cfs	4030 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	2980 cfs	4030 cfs
1 RC	4.35	3.73	2.2	7.1	2.5	2.7	0.01	0.04	0.02	0.02

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2980 cfs	4030 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2980 cfs	4030 cfs
1 MC	---	1.57	0.0	1.7	3.0	None	0.03	0.04

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2028 cfs	2980 cfs	4030 cfs	7374 cfs	Difference (measured vs. pred. WSELs) 2028 cfs	2980 cfs	4030 cfs	7374 cfs
2 LC	1.43	1.93	2.0	1.3	2.5	1.9	0.04	0.03	0.07	0.07

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980 cfs	4030 cfs	7374 cfs	Difference (measured vs. pred. WSELs) 2980 cfs	4030 cfs	7374 cfs
3 RC	2.43	1.09	1.1	1.7	0.6	0.02	0.03	0.01
3 LC	2.94	3.60	4.2	5.6	1.2	0.04	0.06	0.02
4 RC	3.29	1.09	1.2	1.7	0.4	0.01	0.02	0.01
4 LC	2.27	0.56	0.3	0.9	0.5	None	0.01	0.01

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4030 cfs	7374 cfs	Difference (measured vs. pred. WSELs) 4030 cfs	7374 cfs
2 RC	---	0.0	0.0	0.0	None	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4030 cfs	7374 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4030 cfs	7374 cfs	11175 cfs
1 RC	2.77	2.25	1.4	3.5	2.0	0.02	0.07	0.05
2 RC	2.04	0.72	0.5	1.1	0.6	0.01	0.03	0.02
2 LC	1.65	0.31	0.2	0.5	0.2	0.01	0.02	0.01
3 RC	---	0.20	0.0	0.4	0.2	0.00	0.01	0.01
3 LC	---	1.70	3.8	1.3	0.0	0.09	0.03	None
4 RC	2.18	0.67	0.5	1.0	0.5	0.01	0.03	0.02
4 LC	---	1.23	3.1	0.0	0.6	0.10	None	0.02

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4030 cfs	7374 cfs	11107 cfs	Difference (measured vs. pred. WSELs) 4030 cfs	7374 cfs	11107 cfs
1 LMC	2.10	3.12	2.1	4.8	2.5	0.07	0.19	0.12

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 7374 cfs	Difference (measured vs. pred. WSELs) 7374 cfs
4 RC	---	---	---	0.10

Above Sunrise Site

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	Difference (measured vs. pred. WSELs) 1040 cfs
6	---	---	---	0.03

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	2980 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	2980 cfs
2	3.32	3.57	2.4	5.5	3.0	0.03	0.07	0.05
3	3.68	9.32	4.9	15.3	8.7	0.02	0.08	0.06

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs
4	---	9.31	0.0	18.6	None	0.08

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	2980 cfs	4023 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	2980 cfs	4023 cfs
5	4.34	3.21	3.1	4.5	2.0	3.3	0.03	0.06	0.03	0.05
6	4.12	3.45	1.9	5.2	4.9	1.8	0.02	0.05	0.05	0.02
7	4.01	3.24	3.5	6.8	1.1	1.9	0.03	0.07	0.01	0.02

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2028 cfs	2980 cfs	Difference (measured vs. pred. WSELs) 2028 cfs	2980 cfs
1 LC	---	2.22	4.4	0.0	0.10	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2028 cfs	2980 cfs	4023 cfs	Difference (measured vs. pred. WSELs) 2028 cfs	2980 cfs	4023 cfs
2 LC	2.52	3.01	1.4	4.4	3.2	0.03	0.09	0.07

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2028 cfs	2980 cfs	Difference (measured vs. pred. WSELs) 2028 cfs	2980 cfs
2 RC	---	0.00	0.0	0.0	None	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2028 cfs	2980 cfs	7512 cfs	Difference (measured vs. pred. WSELs) 2028 cfs	2980 cfs	7512 cfs
1 RC	2.04	4.86	4.5	7.0	2.8	0.06	0.13	0.08

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980	4023	7512	8948	11175	Difference (measured vs. pred. WSELs) 2980	4023	7512	8948	11175
3	2.15	1.15	1.0	1.0	1.9	1.8	0.0	0.01	0.01	0.04	0.04	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980 cfs	4023 cfs	7512 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 2980 cfs	4023 cfs	7512 cfs	11175 cfs
4	2.51	6.94	9.6	10.4	4.1	3.8	0.09	0.10	0.06	0.07

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4023 cfs	7512 cfs	8948 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4023 cfs	7512 cfs	8948 cfs	11175 cfs
1 LC	2.46	1.29	0.8	2.6	1.3	0.5	0.02	0.09	0.05	0.02
2 RC	1.65	0.08	0.0	0.1	0.2	0.1	None	None	0.01	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4023 cfs	7617 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4023 cfs	7617 cfs	11175 cfs
5	2.31	1.84	0.9	2.7	1.8	0.03	0.10	0.03

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4023 cfs	7512 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4023 cfs	7512 cfs	11175 cfs
6	2.99	1.83	1.2	2.8	1.6	0.02	0.05	0.03
7	2.77	2.94	2.0	4.5	2.4	0.03	0.10	0.06

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 7512 cfs	8948 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 7512 cfs	8948 cfs	11175 cfs
1 RC	---	1.40	3.9	0.3	0.0	0.10	0.01	None
1 LC	1.47	1.09	0.8	1.6	0.9	0.04	0.09	0.05

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 7512 cfs	Difference (measured vs. pred. WSELs) 7512 cfs
2 LC	---	---	---	0.10

Sunrise Site

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs
2 LMC	---	0.00	0.0	0.0	None	None
5	---	0.00	0.0	0.0	None	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	2980 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	2980 cfs
1 LMC	4.40	1.13	0.5	1.7	1.2	0.01	0.03	0.02
3	2.84	1.96	1.2	3.0	1.7	0.02	0.06	0.04
4	2.57	2.88	1.8	4.4	2.5	0.02	0.07	0.05
6	---	---	---	---	---	0.09	0.01	0.10
7	1.37	2.07	1.3	3.2	1.8	0.02	0.06	0.05

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2028 cfs	2980 cfs	4039 cfs	Difference (measured vs. pred. WSELs) 2028 cfs	2980 cfs	4039 cfs
2 RMC	2.50	0.67	0.2	0.1	0.8	None	0.01	0.01

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980 cfs	4039 cfs	Difference (measured vs. pred. WSELs) 2980 cfs	4039 cfs
1 SC	---	1.74	0.0	3.5	None	0.01

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980 cfs	4039 cfs	7512 cfs	Difference (measured vs. pred. WSELs) 2980 cfs	4039 cfs	7512 cfs
2 LMC	3.34	2.32	2.3	3.4	1.2	0.06	0.10	0.04

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980 cfs	4039 cfs	7512 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 2980 cfs	4039 cfs	7512 cfs	11175 cfs
3	3.47	1.59	1.8	2.8	1.3	0.4	0.03	0.05	0.03	0.01
4	2.78	1.58	1.8	1.8	1.4	1.3	0.03	0.03	0.03	0.04
5	2.56	3.25	3.8	3.5	3.1	2.6	0.08	0.08	0.08	0.09
6	2.42	3.20	4.2	4.3	2.2	2.2	0.08	0.09	0.06	0.07
7	---	1.75	0.0	4.2	1.2	1.6	None	0.09	0.04	0.06

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4039 cfs	7512 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4039 cfs	7512 cfs	11175 cfs
1 RMC	1.19	6.96	3.3	11.1	6.6	0.01	0.11	0.13
1 LMC	2.28	0.70	0.4	1.0	0.7	0.02	0.05	0.04
1 SC	2.02	4.45	2.4	7.0	4.2	0.02	0.11	0.10
2 RMC	2.00	1.35	0.8	2.1	1.3	0.01	0.04	0.03

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 2980 cfs	7512 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 2980 cfs	7512 cfs	11175 cfs
2 SC	1.33	0.51	0.1	0.8	0.7	None	0.01	0.01

El Manto Site

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	3042 cfs	4039 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	3042 cfs	4039 cfs
1	---	3.25	6.7	6.3	0.0	0.0	0.06	0.07	None	None
2	2.83	2.23	2.5	4.6	0.1	1.9	0.03	0.06	None	0.03

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4039 cfs	7532 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4039 cfs	7532 cfs	11175 cfs
1	2.67	1.78	1.1	2.7	1.5	0.03	0.09	0.06
2	---	---	---	---	---	0.03	0.09	0.07

Rossmoor Site

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	3116 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	3116 cfs
6	2.56	1.39	0.9	2.1	1.2	0.01	0.03	0.02

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040 cfs	2028 cfs	3116 cfs	4039 cfs	Difference (measured vs. pred. WSELs) 1040 cfs	2028 cfs	3116 cfs	4039 cfs
1 RC	2.33	1.33	1.3	2.7	0.3	1.0	0.01	0.04	0.01	0.02
1 LC	2.93	4.18	3.5	8.4	4.7	0.3	0.02	0.07	0.05	None
2 LC	5.71	6.28	6.7	13.1	0.4	5.6	0.03	0.07	None	0.04
3	3.22	0.14	0.0	0.1	0.3	0.2	None	None	None	None
7	2.81	2.68	0.9	0.7	4.6	4.5	0.01	0.01	0.07	0.08

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1040	2028	3116	4039	7532	Difference (measured vs. pred. WSELs) 1040	2028	3116	4039	7532
2 RC	2.38	3.25	3.1	6.2	4.1	2.2	0.8	0.04	0.09	0.07	0.04	0.02
4	2.61	1.43	0.4	2.3	0.8	2.5	1.2	0.01	0.04	0.02	0.05	0.03
5	2.85	2.04	1.0	1.8	3.4	1.7	2.3	0.01	0.03	0.06	0.03	0.05

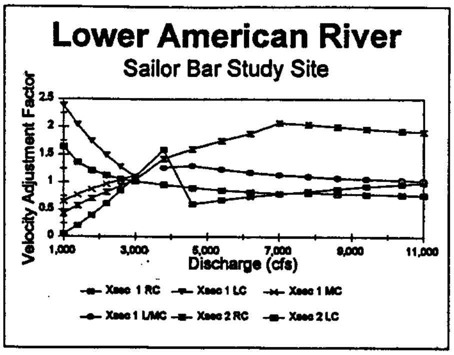
XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 4039 cfs	7532 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 4039 cfs	7532 cfs	11175 cfs
1 RC	---	2.63	4.3	3.6	0.0	0.08	0.09	None
2 RC	1.99	3.22	2.2	5.0	2.6	0.05	0.14	0.11
2 LC	2.41	2.33	1.4	3.6	2.0	0.03	0.09	0.06
3	2.30	0.34	0.2	0.5	0.3	None	0.02	0.01
6	2.09	1.23	0.8	1.9	1.1	0.02	0.06	0.04
7	1.99	1.37	0.9	2.1	1.2	0.02	0.07	0.05

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 7532 cfs	11175 cfs	Difference (measured vs. pred. WSELs) 7532 cfs	11175 cfs
1 LC	---	0.0	0.0	0.0	None	None
4	---	---	---	---	0.02	0.06
5	---	---	---	---	0.06	0.02

APPENDIX C
VELOCITY CALIBRATION

SAILOR BAR STUDY SITE

Discharge	Velocity Adjustment Factors Xsec 1 RC	Xsec 1 LC	Xsec 1 MC	Xsec 1 L/MC	Xsec 2 RC	Xsec 2 LC
1000	0.05	2.39	0.65	—	0.42	1.65
1400	0.20	2.05	0.77	—	0.57	1.36
1800	0.40	1.75	0.88	—	0.71	1.22
2200	0.61	1.50	0.97	—	0.82	1.13
2600	0.85	1.28	1.04	—	0.93	1.06
3000	1.09	1.09	1.12	—	1.04	1.01
3800	1.59	—	—	1.26	1.42	0.95
4600	0.60	—	—	1.30	1.60	0.90
5400	0.68	—	—	1.23	1.75	0.86
6200	0.74	—	—	1.18	1.88	0.83
7000	0.79	—	—	1.14	2.08	0.80
7800	0.84	—	—	1.11	2.05	0.81
8600	0.88	—	—	1.08	2.00	0.80
9400	0.92	—	—	1.06	1.97	0.79
10400	0.97	—	—	1.04	1.93	0.78
11000	1.00	—	—	1.03	1.91	0.77



TRANSECT 1 LC	meas	3,024 CFS VELOCITY SET USED sim	sim	sim
	3,024	1,000	3,024	3,000
avg	1.31	3.09	1.47	1.35
std dev	0.58	0.63	0.66	0.71
max	2.12	4.04	2.38	2.33
avg diff			**0.16**	
+/-			**2.06**	
max diff			**0.26**	

TRANSECT 1 MC	meas	3,024 CFS VELOCITY SET USED sim	sim	sim
	3,024	1,000	3,024	3,000
avg	1.56	0.92	1.73	1.74
std dev	2.11	1.13	2.35	2.36
max	7.10	3.02	7.87	7.90
avg diff			**0.21**	
+/-			**6.57**	
max diff			**0.77**	

TRANSECT 1 RC	meas	3,024 CFS VELOCITY SET USED sim	sim	sim
	3,024	1,000	3,024	11,000
avg	0.40	0.02	0.43	3.13
std dev	1.19	0.05	1.28	1.09
max	3.15	0.12	3.40	4.62
avg diff			**0.06**	
+/-			**0.83**	
max diff			**0.25**	

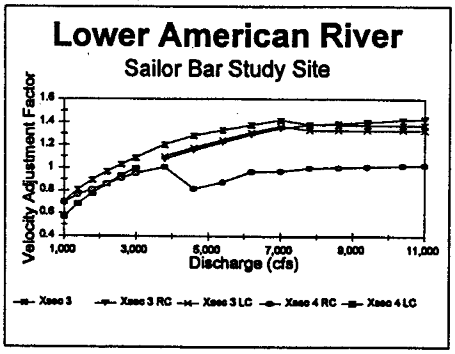
TRANSECT 1 L/MC	meas	11,107 CFS VELOCITY SET USE sim	sim	sim
	11,107	3,400	11,107	11,000
avg	2.47	2.03	2.52	2.89
std dev	2.45	2.19	2.50	2.57
max	7.31	6.23	7.48	7.47
avg diff			**0.05**	
+/-			**1.27**	
max diff			**0.17**	

TRANSECT 2 LC	meas	3,024 CFS VELOCITY SET USED sim	sim	sim
	3,024	1,000	3,024	11,000
avg	3.96	4.21	3.99	4.42
std dev	2.55	2.47	2.58	3.17
max	9.41	10.22	9.50	11.71
avg diff			**0.03**	
+/-			**1.07**	
max diff			**0.09**	

TRANSECT 2 RC	meas	3,024 CFS VELOCITY SET USED sim	sim	sim
	3,024	1,000	3,024	11,000
avg	1.50	0.32	1.51	4.68
std dev	0.66	0.18	0.67	2.15
max	2.48	0.56	2.51	7.65
avg diff			**0.02**	
+/-			**0.37**	
max diff			**0.03**	

SAILOR BAR STUDY SITE

Discharge	Velocity Adjustment Factors Xsec 3	Xsec 3 RC	Xsec 3 LC	Xsec 4 RC	Xsec 4 LC
1000	0.57	—	—	0.69	0.70
1400	0.68	—	—	0.76	0.81
1800	0.77	—	—	0.81	0.89
2200	0.86	—	—	0.86	0.97
2600	0.93	—	—	0.90	1.03
3000	1.00	—	—	0.95	1.08
3800	—	1.08	1.10	1.01	1.20
4600	—	1.16	1.18	0.82	1.28
5400	—	1.22	1.24	0.87	1.33
6200	—	1.29	1.31	0.97	1.37
7000	—	1.34	1.36	0.97	1.42
7800	—	1.38	1.33	1.00	1.38
8600	—	1.39	1.33	1.00	1.38
9400	—	1.40	1.33	1.01	1.37
10400	—	1.42	1.33	1.02	1.37
11000	—	1.43	1.33	1.03	1.37



TRANSECT 3

	meas	sim	sim	sim
	3,024	1,000	3,024	3,000
		3,024 CFS VELOCITY SET USED		
avg	2.03	0.79	1.99	1.98
std dev	0.63	0.33	0.62	0.63
max	3.36	1.76	3.32	3.33
avg diff			0.04	
+/-			-1.82	
max diff			0.08	

TRANSECT 3 LC

	meas	sim	sim	sim
	3,024	3,400	3,024	11,000
		3,024 CFS VELOCITY SET USED		
avg	2.03	2.16	2.07	4.23
std dev	0.67	0.84	0.68	2.01
max	2.83	3.11	2.88	7.12
avg diff			0.03	
+/-			0.89	
max diff			0.06	

TRANSECT 3 RC

	meas	sim	sim	sim
	3,024	3,400	3,024	11,000
		3,024 CFS VELOCITY SET USED		
avg	2.01	2.00	1.93	3.87
std dev	0.56	0.68	0.55	1.03
max	3.36	3.48	3.24	5.77
avg diff			0.08	
+/-			-1.46	
max diff			0.12	

TRANSECT 4 LC

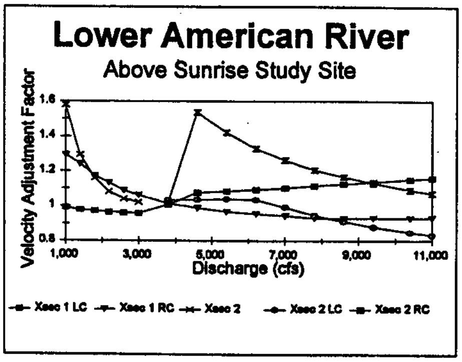
	meas	sim	sim	sim
	3,024	1,000	3,024	11,000
		3,024 CFS VELOCITY SET USED		
avg	1.86	0.96	2.02	3.45
std dev	0.88	0.45	0.95	2.00
max	3.36	1.75	3.63	7.79
avg diff			0.16	
+/-			4.76	
max diff			0.27	

TRANSECT 4 RC

	meas	sim	sim	sim
	3,024	1,000	3,024	11,000
		3,024 CFS VELOCITY SET USED		
avg	2.59	1.28	2.40	6.20
std dev	1.81	0.88	1.68	2.37
max	7.86	3.96	7.29	9.05
avg diff			0.19	
+/-			-7.09	
max diff			0.57	

ABOVE SUNRISE STUDY SITE

	Velocity Adjustment Factors				
Discharge	Xsec 1 LC	Xsec 1 RC	Xsec 2	Xsec 2 LC	Xsec 2 RC
1000	0.99	1.29	1.58	—	—
1400	0.98	1.24	1.29	—	—
1800	0.97	1.17	1.16	—	—
2200	0.96	1.13	1.08	—	—
2600	0.96	1.09	1.04	—	—
3000	0.96	1.06	1.02	—	—
3800	1.01	1.01	—	1.03	1.02
4600	1.07	0.99	—	1.03	1.54
5400	1.08	0.97	—	1.04	1.42
6200	1.09	0.95	—	1.03	1.33
7000	1.10	0.94	—	0.99	1.26
7800	1.11	0.93	—	0.95	1.20
8600	1.12	0.93	—	0.91	1.16
9400	1.13	0.93	—	0.88	1.13
10400	1.15	0.93	—	0.85	1.09
11000	1.16	0.93	—	0.83	1.07



TRANSECT 1 LC		3,114 CFS VELOCITY SET USED		
	meas	sim	sim	sim
	3,114	1,000	3,114	11,000
avg	3.16	2.08	3.02	5.04
std dev	1.26	0.92	1.21	2.51
max	4.83	3.73	4.62	8.65
avg diff			**0.14**	
+/-			**-3.09**	
max diff			**0.21**	

TRANSECT 1 RC		3,114 CFS VELOCITY SET USE		
	meas	sim	sim	sim
	3,114	1,000	3,114	11,000
avg	1.13	2.24	2.97	4.85
std dev	4.67	0.91	1.20	1.63
max	2.93	3.41	4.81	9.34
avg diff			**0.08**	
+/-			**1.13**	
max diff			**0.17**	

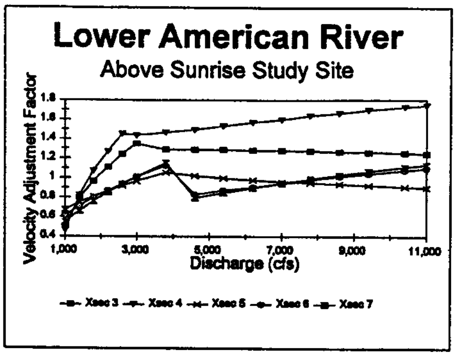
TRANSECT 2		3,114 CFS VELOCITY SET USED		
	meas	sim	sim	sim
	3,114	1,000	3,114	3,000
avg	3.91	3.73	3.94	3.95
std dev	1.93	1.76	1.96	1.96
max	9.49	8.15	9.56	9.58
avg diff			**0.04**	
+/-			**1.55**	
max diff			**0.15**	

TRANSECT 2 LC		3,114 CFS VELOCITY SET USED		
	meas	sim	sim	sim
	3,114	3,400	3,114	11,000
avg	3.97	3.97	4.04	4.04
std dev	1.96	2.24	2.00	3.47
max	6.55	6.88	6.71	8.72
avg diff			**0.07**	
+/-			**1.12**	
max diff			**0.16**	

TRANSECT 2 RC		3,114 CFS VELOCITY SET USE		
	meas	sim	sim	sim
	3,114	3,400	3,114	11,000
avg	3.90	3.92	3.76	5.58
std dev	1.87	1.96	1.92	2.14
max	9.49	9.68	9.37	8.94
avg diff			**0.06**	
+/-			**-2.88**	
max diff			**0.15**	

ABOVE SUNRISE STUDY SITE

Discharge	Velocity Adjustment Factors Xsec 3	Xsec 4	Xsec 5	Xsec 6	Xsec 7
1000	0.51	0.47	0.67	0.61	0.55
1400	0.80	0.83	0.75	0.71	0.66
1800	0.97	1.07	0.81	0.80	0.76
2200	1.11	1.27	0.87	0.87	0.85
2600	1.24	1.45	0.92	0.94	0.93
3000	1.35	1.44	0.97	1.01	1.01
3800	1.29	1.47	1.05	1.12	1.16
4600	1.29	1.49	1.02	0.83	0.80
5400	1.29	1.53	1.00	0.87	0.85
6200	1.28	1.57	0.98	0.91	0.90
7000	1.28	1.60	0.96	0.94	0.95
7800	1.27	1.64	0.95	0.98	0.99
8600	1.26	1.66	0.93	1.01	1.03
9400	1.25	1.69	0.92	1.04	1.06
10400	1.25	1.72	0.91	1.07	1.11
11000	1.24	1.74	0.90	1.09	1.13



TRANSECT 3 — 3,114 CFS VELOCITY SET USED

	meas 3,114	sim 1,000	sim 3,114	sim 11,000
avg	2.71	0.93	3.46	3.94
std dev	1.13	0.31	1.45	2.79
max	4.51	1.25	5.75	10.28
avg diff			0.75	
+/-			11.19	
max diff			1.24	

TRANSECT 4 — 3,114 CFS VELOCITY SET USED

	meas 3,114	sim 1,000	sim 3,114	sim 11,000
avg	0.96	0.31	1.36	2.79
std dev	0.56	0.15	0.77	1.68
max	1.90	0.57	2.65	5.77
avg diff			0.37	
+/-			12.31	
max diff			0.75	

TRANSECT 5 — 3,114 CFS VELOCITY SET USED

	meas 3,114	sim 1,000	sim 3,114	sim 11,000
avg	3.65	1.98	3.54	3.54
std dev	3.93	2.16	3.81	3.81
max	9.82	5.05	9.52	14.42
avg diff			0.12	
+/-			-2.08	
max diff			0.30	

TRANSECT 6 — 3,114 CFS VELOCITY SET USED

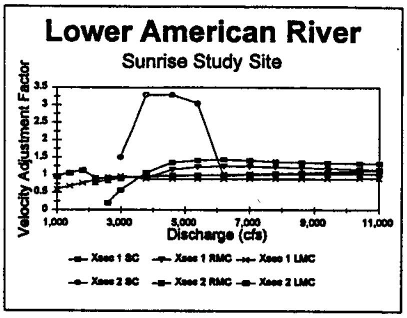
	meas 3,114	sim 1,000	sim 3,114	sim 11,000
avg	2.11	0.98	2.09	3.92
std dev	0.90	0.48	0.89	2.69
max	4.94	2.34	4.90	7.26
avg diff			0.02	
+/-			-1.15	
max diff			0.04	

TRANSECT 7 — 3,024 CFS VELOCITY SET USED

	meas 3,024	sim 1,000	sim 3,024	sim 11,000
avg	1.41	0.63	1.42	2.93
std dev	1.64	0.73	1.65	3.28
max	6.90	3.00	6.94	9.18
avg diff			0.01	
+/-			0.58	
max diff			0.04	

SUNRISE STUDY SITE

Discharge	Velocity Adjustment Factors Xsec 1 SC	Xsec 1 RMC	Xsec 1 LMC	Xsec 2 SC	Xsec 2 RMC	Xsec 2 LMC
1000	—	—	0.59	—	—	0.96
1400	—	—	0.69	—	—	1.06
1800	—	—	0.77	—	—	1.13
2200	—	—	0.85	—	0.79	0.91
2600	0.20	—	0.92	—	0.84	0.92
3000	0.56	—	0.97	1.51	0.90	0.93
3800	1.06	0.92	0.88	3.29	0.96	0.94
4600	1.35	1.15	0.88	3.28	0.98	0.96
5400	1.42	1.22	0.88	3.04	0.99	0.98
6200	1.43	1.24	0.88	0.97	0.99	1.00
7000	1.40	1.23	0.88	1.00	1.00	1.02
7800	1.37	1.21	0.88	1.02	1.00	1.04
8600	1.35	1.19	0.88	1.03	1.01	1.06
9400	1.33	1.17	0.88	1.03	1.01	1.07
10400	1.31	1.14	0.88	1.03	1.01	1.10
11000	1.30	1.13	0.89	0.99	1.02	1.11



TRANSECT 1 SC	meas 4,039	4,039 CFS VELOCITY SET USED sim 2,600	sim 4,039	sim 11,000
avg	2.59	0.29	3.13	4.21
std dev	1.83	0.22	2.21	2.62
max	5.48	0.58	6.63	12.05
avg diff			0.54	
+/-			5.40	
max diff			1.15	

TRANSECT 1 RMC	meas 4,039	4,039 CFS VELOCITY SET USED sim 3,400	sim 4,039	sim 11,000
avg	1.79	0.71	1.81	3.97
std dev	0.58	0.31	0.59	1.51
max	2.82	1.25	2.86	7.52
avg diff			0.03	
+/-			0.54	
max diff			0.04	

TRANSECT 1 LMC	meas 3,114	3,114 CFS VELOCITY SET USED sim 1,000	sim 3,114	sim 11,000
avg	3.27	1.40	2.68	2.79
std dev	2.63	1.25	2.45	2.89
max	7.08	3.54	6.83	8.19
avg diff			0.10	
+/-			-2.29	
max diff			0.25	

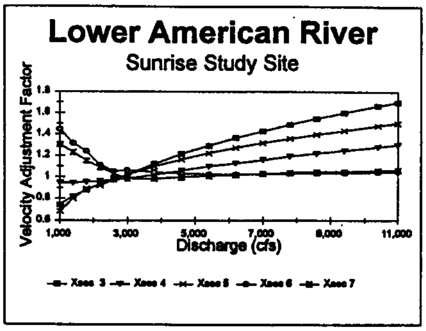
TRANSECT 2 SC	meas 3,114	3,114 CFS VELOCITY SET USED sim 3,000	sim 3,114	sim 11,000
avg	0.51	0.91	1.13	1.93
std dev	0.30	0.69	0.47	1.29
max	0.90	2.09	1.82	4.06
avg diff			0.62	
+/-			3.72	
max diff			0.92	

TRANSECT 2 RMC	meas 2,980	2,980 CFS VELOCITY SET USED sim 2,200	sim 2,980	sim 11,000
avg	2.03	1.05	1.80	3.60
std dev	0.86	0.52	0.76	1.44
max	4.60	2.30	4.08	8.35
avg diff			0.23	
+/-			-5.27	
max diff			0.52	

TRANSECT 2 LMC	meas 2,980	2,980 CFS VELOCITY SET USED sim 1,000	sim 2,980	sim 11,000
avg	4.74	3.36	4.45	7.60
std dev	1.51	1.55	1.40	2.44
max	8.26	6.46	7.70	11.20
avg diff			0.29	
+/-			-5.76	
max diff			0.56	

SUNRISE STUDY SITE

	Velocity Adjustment Factors				
Discharge	Xsec 3	Xsec 4	Xsec 5	Xsec 6	Xsec 7
1000	0.74	0.95	0.68	1.45	1.30
1400	0.82	0.94	0.80	1.31	1.23
1800	0.88	0.95	0.89	1.24	1.15
2200	0.93	0.96	0.92	1.11	1.09
2600	0.98	0.97	0.97	1.05	1.03
3000	1.02	0.99	1.02	1.06	0.98
3800	1.12	1.02	1.10	1.04	0.98
4600	1.21	1.06	1.16	1.03	1.00
5400	1.29	1.10	1.22	1.03	1.01
6200	1.36	1.13	1.27	1.02	1.02
7000	1.43	1.16	1.32	1.03	1.03
7800	1.49	1.19	1.36	1.03	1.04
8600	1.55	1.22	1.40	1.03	1.04
9400	1.60	1.25	1.43	1.03	1.05
10400	1.66	1.28	1.48	1.04	1.06
11000	1.70	1.30	1.50	1.05	1.06



TRANSECT 3	meas	3,114 CFS VELOCITY SET USED		
		sim	sim	sim
	3,114	1,000	3,114	11,000
avg	1.99	1.26	2.01	3.77
std dev	1.51	0.77	1.54	3.38
max	4.57	2.39	4.62	11.57
avg diff			0.03	
+/-			1.18	
max diff			0.07	

TRANSECT 4	meas	3,114 CFS VELOCITY SET USED		
		sim	sim	sim
	3,114	1,000	3,114	11,000
avg	2.12	1.25	2.08	3.90
std dev	1.28	0.89	1.25	2.47
max	4.50	3.10	4.41	9.20
avg diff			0.05	
+/-			-2.94	
max diff			0.11	

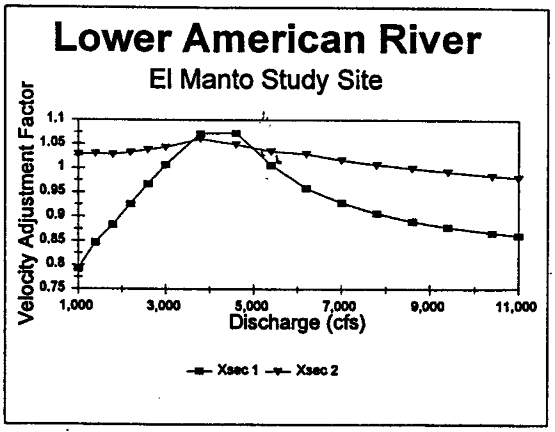
TRANSECT 5	meas	3,114 CFS VELOCITY SET USED		
		sim	sim	sim
	3,114	1,000	3,114	11,000
avg	2.06	0.89	2.07	3.67
std dev	1.50	0.83	1.51	3.03
max	5.37	2.70	5.39	11.93
avg diff			0.01	
+/-			0.49	
max diff			0.04	

TRANSECT 6	meas	3,114 CFS VELOCITY SET USED		
		sim	sim	sim
	3,114	1,000	3,114	11,000
avg	2.25	1.82	2.19	3.54
std dev	1.52	1.32	1.49	2.76
max	6.27	3.96	6.13	11.13
avg diff			0.06	
+/-			-3.39	
max diff			0.16	

TRANSECT 7	meas	3,114 CFS VELOCITY SET USED		
		sim	sim	sim
	3,114	1,000	3,114	11,000
avg	2.10	1.52	2.01	3.46
std dev	0.76	0.80	0.73	1.40
max	3.41	3.23	3.27	6.01
avg diff			0.08	
+/-			-4.93	
max diff			0.14	

EL MANTO STUDY SITE

Discharge	Velocity Adjustment Factors Xsec 1	Xsec 2
1000.00	0.79	1.03
1400.00	0.85	1.03
1800.00	0.88	1.03
2200.00	0.93	1.03
2600.00	0.97	1.04
3000.00	1.01	1.04
3800.00	1.07	1.06
4600.00	1.07	1.05
5400.00	1.01	1.03
6200.00	0.96	1.03
7000.00	0.93	1.02
7800.00	0.91	1.01
8600.00	0.89	1.00
9400.00	0.88	0.99
10400.00	0.87	0.98
11000.00	0.86	0.98

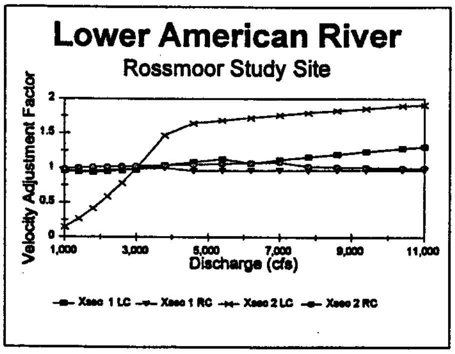


TRANSECT 1	meas 3,042		3,042 CFS VELOCITY SET USED sim 1,000	sim 3,042	sim 11,000
avg	3.56		1.92	3.58	5.24
std dev	2.20		1.34	2.22	3.70
max	8.70		5.16	8.77	13.37
avg diff				**0.03**	
+/-				**1.28**	
max diff				**0.07**	

TRANSECT 2	meas 3,042		3,042 CFS VELOCITY SET USED sim 1,000	sim 3,042	sim 11,000
avg	3.86		2.47	1.61	6.17
std dev	1.54		1.26	4.03	3.00
max	7.40		5.00	7.74	12.63
avg diff				**0.18**	
+/-				**5.97**	
max diff				**0.34**	

Rossmoor Study Site

Discharge	Velocity Adjustment Factors Xsec 1 LC	Xsec 1 RC	Xsec 2 LC	Xsec 2 RC
1000	0.96	0.96	0.14	0.99
1400	0.94	0.96	0.26	1.00
1800	0.94	0.96	0.41	1.01
2200	0.95	0.97	0.59	1.02
2600	0.96	0.98	0.78	1.02
3000	0.98	0.99	0.99	1.03
3800	1.04	1.00	1.47	1.04
4600	1.09	0.96	1.64	1.05
5400	1.13	0.96	1.68	1.06
6200	1.07	0.96	1.72	1.07
7000	1.12	0.97	1.76	1.08
7800	1.16	0.96	1.79	1.02
8600	1.20	0.97	1.82	1.02
9400	1.24	0.97	1.85	1.01
10400	1.28	0.97	1.89	1.00
11000	1.30	0.97	1.91	1.00



TRANSECT 1 LC	meas 3,116	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	2.87	1.70	2.93	4.94
std dev	1.57	0.95	1.60	4.74
max	4.80	2.91	4.92	10.77
avg diff			0.06	
+/-			0.97	
max diff			0.12	

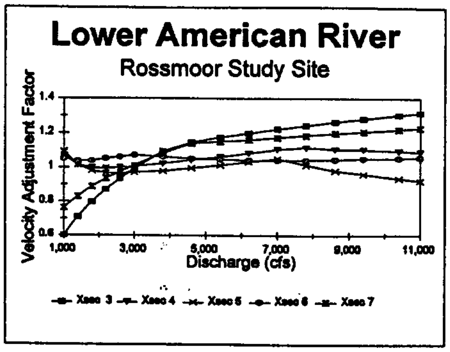
TRANSECT 1 RC	meas	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	4.89	3.02	4.84	7.55
std dev	1.22	1.01	1.21	1.66
max	6.70	4.65	6.65	9.82
avg diff			0.04	
+/-			-1.30	
max diff			0.05	

TRANSECT 2 LC	meas	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	1.07	0.10	1.13	3.44
std dev	1.16	0.12	1.22	3.71
max	3.24	0.33	3.41	9.45
avg diff			0.07	
+/-			1.48	
max diff			0.17	

TRANSECT 2 RC	meas	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	3.80	2.80	3.84	5.67
std dev	1.53	1.12	1.57	2.02
max	6.51	4.52	6.61	9.75
avg diff			0.07	
+/-			1.48	
max diff			0.17	

Rossmoor Study Site

Discharge	Velocity Adjustment Factors Xsec 3	Xsec 4	Xsec 5	Xsec 6	Xsec 7
1000	0.60	1.07	1.10	1.05	0.76
1400	0.71	1.01	1.01	1.04	0.83
1800	0.80	1.00	0.98	1.04	0.89
2200	0.87	0.99	0.97	1.05	0.94
2600	0.94	1.00	0.97	1.06	0.97
3000	0.99	1.00	0.97	1.07	1.01
3800	1.09	1.02	0.98	1.06	1.08
4600	1.15	1.04	1.00	1.05	1.14
5400	1.17	1.06	1.01	1.05	1.15
6200	1.20	1.08	1.03	1.04	1.16
7000	1.22	1.11	1.05	1.04	1.17
7800	1.24	1.12	1.01	1.04	1.19
8600	1.27	1.11	0.98	1.05	1.20
9400	1.28	1.10	0.96	1.05	1.21
10400	1.30	1.10	0.94	1.05	1.22
11000	1.32	1.09	0.92	1.06	1.23



TRANSECT 3

	meas 3,116	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	2.03	0.84	2.05	3.96
std dev	1.66	0.85	1.68	3.37
max	5.07	2.19	5.12	10.55
avg diff			0.02	
+/-			1.20	
max diff			0.05	

TRANSECT 4

	meas 3,116	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	2.79	2.03	2.81	3.76
std dev	2.03	1.29	2.05	3.64
max	7.78	5.08	7.85	13.66
avg diff			0.02	
+/-			1.09	
max diff			0.07	

TRANSECT 5

	meas 3,116	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	3.21	2.18	3.16	4.74
std dev	1.34	0.99	1.31	2.12
max	6.93	4.92	6.80	10.43
avg diff			0.05	
+/-			-2.51	
max diff			0.13	

TRANSECT 6

	meas 3,116	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	2.49	1.65	2.67	4.36
std dev	1.22	0.90	1.31	2.10
max	6.45	4.57	6.92	10.85
avg diff			0.18	
+/-			9.68	
max diff			0.47	

TRANSECT 7

	meas 3,116	3,116 Velocity Set Used sim 1,000	sim 3,116	sim 11,000
avg	2.57	1.42	2.59	4.56
std dev	0.99	0.47	1.00	2.11
max	4.72	2.28	4.76	9.39
avg diff			0.02	
+/-			0.94	
max diff			0.04	

APPENDIX D
HSI CRITERIA

Fall-run Chinook Salmon Spawning Criteria

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.1	0.00
0.10	0.02	0.50	0.00	1	0.00
0.30	0.04	0.60	0.25	1.2	0.36
0.40	0.07	0.70	0.31	1.3	1.00
0.70	0.15	0.90	0.43	1.4	0.97
0.90	0.25	1.00	0.50	2.4	0.97
1.00	0.32	1.10	0.56	3.4	0.53
1.10	0.38	1.20	0.64	3.5	0.28
1.20	0.46	1.30	0.70	3.6	0.00
1.30	0.53	1.40	0.77	100.0	0.00
1.40	0.62	1.50	0.82		
1.50	0.70	1.60	0.89		
1.60	0.78	1.80	0.97		
1.70	0.85	1.90	0.98		
1.80	0.91	2.00	1.00		
1.90	0.96	2.10	1.00		
2.00	0.99	10.80	0.00		
2.10	1.00	100.00	0.00		
2.20	0.99				
2.30	0.97				
2.40	0.93				
2.50	0.88				
2.60	0.80				
2.70	0.73				
2.80	0.67				
2.90	0.56				
3.00	0.49				
3.10	0.40				
3.30	0.28				
3.40	0.21				
3.60	0.13				
3.80	0.07				
4.00	0.03				
4.20	0.01				
4.30	0.00				
100.00	0.00				

Steelhead Spawning Criteria

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0.00	0.00	0.00	0.00	0.1	0.00
0.29	0.00	0.70	0.00	1	0.00
0.31	0.53	0.73	0.32	1.2	0.30
0.70	0.97	1.30	0.87	2.3	1.00
0.79	1.00	1.51	1.00	2.4	0.30
0.88	1.00	100.00	1.00	3.4	0.00
1.14	0.90			100.0	0.00
1.61	0.62				
2.00	0.49				
3.39	0.49				
3.61	0.38				
4.20	0.00				
100.00	0.00				

APPENDIX E
HABITAT MODELING RESULTS

Sailor Bar Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 1 LC	XS 1 RC	XS 1 MC	XS 1 L\MC	XS 2 LC	XS 2 RC
1000	10.1	0.1	68.9	---	15.4	2.0
1200	10.8	0.4	62.2	---	18.5	4.0
1400	11.5	0.6	53.7	---	21.3	6.9
1600	12.0	1.0	47.8	---	23.3	11.5
1800	12.3	1.4	44.4	---	24.8	17.3
2000	12.6	2.0	43.2	---	25.5	24.5
2200	12.5	2.7	43.4	---	25.5	33.2
2400	12.1	3.4	44.5	---	25.5	42.5
2600	11.7	4.1	46.0	---	25.1	51.7
2800	11.1	4.6	47.8	---	24.5	60.3
3000	10.4	5.0	49.6	---	24.1	67.4
3400	---	5.8	---	55.7	24.1	72.1
3800	---	7.2	---	55.7	23.8	57.0
4200	---	10.8	---	52.6	23.6	43.5
4600	---	16.7	---	54.6	23.5	30.3
5000	---	24.8	---	61.3	23.2	20.7
5400	---	35.2	---	66.5	22.8	14.5
5800	---	48.2	---	75.6	22.4	10.9
6200	---	64.3	---	79.9	21.9	9.2
6600	---	80.9	---	80.5	21.5	9.0
7000	---	96.6	---	78.5	21.0	8.9
7400	---	110.3	---	73.0	20.8	9.0
7800	---	120.2	---	66.0	20.4	9.1
8200	---	125.2	---	58.7	20.0	9.1
8600	---	125.2	---	51.2	19.5	9.1
9000	---	119.4	---	45.4	19.2	9.1
9400	---	109.2	---	39.7	18.8	9.2
9800	---	96.6	---	35.7	18.4	9.2
10400	---	74.8	---	30.5	17.8	9.4
11000	---	54.4	---	25.9	17.2	9.5

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sailor Bar Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 3	XS 3 LC	XS 3 RC	XS 4 LC	XS 4 RC
1000	37.6	---	---	55.9	95.3
1200	53.7	---	---	67.0	106.1
1400	72.3	---	---	76.9	111.4
1600	92.3	---	---	85.3	113.5
1800	113.2	---	---	91.1	111.0
2000	133.3	---	---	94.2	107.0
2200	152.0	---	---	94.6	100.9
2400	167.2	---	---	92.9	93.9
2600	179.3	---	---	89.6	86.6
2800	187.2	---	---	85.5	78.9
3000	191.3	---	---	84.8	71.2
3400	---	96.8	89.5	76.4	59.2
3800	---	86.3	94.9	67.4	48.4
4200	---	73.5	96.9	57.5	30.5
4600	---	60.6	96.3	52.5	22.6
5000	---	51.0	94.0	47.8	17.8
5400	---	44.1	90.4	43.7	14.2
5800	---	38.5	85.2	39.8	11.6
6200	---	34.7	79.4	35.9	9.1
6600	---	31.6	72.1	32.3	7.5
7000	---	28.7	65.2	29.4	6.9
7400	---	27.1	58.6	28.3	5.8
7800	---	25.3	52.1	26.3	5.1
8200	---	23.8	45.9	24.3	4.5
8600	---	22.4	40.3	22.1	4.0
9000	---	21.1	34.7	20.2	3.4
9400	---	19.7	30.2	18.6	3.0
9800	---	18.7	26.0	17.1	2.6
10400	---	17.3	20.5	15.0	2.1
11000	---	16.0	16.3	13.1	1.7

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sailor Bar Study Site - Steelhead Spawning

Flow	XS 1 LC	XS 1 RC	XS 1 MC	XS 1 L\MC	XS 2 LC	XS 2 RC
1000	3.4	0.0	27.4	---	6.9	4.5
1200	3.8	0.0	28.5	---	9.8	8.4
1400	4.3	1.3	30.1	---	12.0	11.4
1600	4.8	3.3	29.9	---	12.6	13.5
1800	5.3	5.2	28.4	---	12.5	14.4
2000	5.7	6.8	26.2	---	12.7	15.2
2200	6.1	7.7	23.9	---	12.6	14.6
2400	6.2	8.3	22.9	---	12.7	14.7
2600	6.3	9.5	22.5	---	12.6	13.8
2800	7.8	9.9	21.9	---	12.5	15.1
3000	8.9	10.8	20.9	---	12.4	15.0
3400	---	12.3	---	19.0	12.2	14.9
3800	---	23.4	---	19.1	11.9	15.6
4200	---	16.9	---	20.1	11.3	16.1
4600	---	21.5	---	21.4	10.7	15.9
5000	---	25.4	---	21.7	10.1	14.5
5400	---	27.2	---	25.4	9.8	12.0
5800	---	30.7	---	27.3	9.3	9.6
6200	---	31.0	---	28.6	9.0	8.0
6600	---	32.3	---	29.8	8.6	6.8
7000	---	31.4	---	30.4	8.2	6.8
7400	---	30.3	---	30.6	7.4	6.6
7800	---	28.2	---	30.4	7.0	6.5
8200	---	27.1	---	30.0	6.7	6.3
8600	---	26.2	---	29.5	6.4	6.3
9000	---	25.7	---	28.9	6.1	6.2
9400	---	25.7	---	28.3	5.9	6.1
9800	---	25.7	---	27.4	5.6	6.1
10400	---	25.7	---	26.1	5.3	6.0
11000	---	25.4	---	24.6	5.1	5.9

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sailor Bar Study Site - Steelhead Spawning

Flow	XS 3	XS 3 LC	XS 3 RC	XS 4 LC	XS 4 RC
1000	69.9	---	---	35.5	34.6
1200	74.0	---	---	33.8	35.0
1400	76.5	---	---	32.0	34.6
1600	75.9	---	---	30.1	33.9
1800	73.7	---	---	28.8	32.9
2000	71.0	---	---	27.5	31.9
2200	68.0	---	---	26.5	31.3
2400	65.7	---	---	25.7	30.6
2600	63.1	---	---	25.2	29.5
2800	61.0	---	---	24.8	28.3
3000	59.3	---	---	24.9	26.9
3400	---	26.3	30.4	24.0	24.1
3800	---	25.9	28.4	23.0	21.4
4200	---	25.3	26.9	21.7	14.2
4600	---	23.2	26.1	20.6	10.5
5000	---	20.3	25.9	19.6	8.1
5400	---	17.3	25.9	18.5	7.1
5800	---	14.5	25.9	17.5	6.7
6200	---	12.2	25.9	16.6	6.1
6600	---	10.1	25.8	15.8	5.5
7000	---	8.4	25.6	15.0	5.2
7400	---	8.3	25.5	15.1	5.0
7800	---	7.7	25.4	14.6	4.8
8200	---	7.3	25.2	14.2	4.6
8600	---	7.0	24.8	13.7	4.5
9000	---	6.7	24.4	13.4	4.3
9400	---	6.5	24.0	13.2	4.1
9800	---	6.3	23.5	12.9	4.0
10400	---	6.0	22.8	12.6	3.7
11000	---	5.7	21.7	12.3	3.5

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Above Sunrise Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 1 LC	XS 1 RC	XS 2	XS 2 LC	XS 2 RC
1000	61.5	36.4	25.5	---	---
1200	57.4	30.8	34.7	---	---
1400	50.7	23.8	41.7	---	---
1600	42.9	21.9	44.6	---	---
1800	34.3	22.3	45.5	---	---
2000	28.0	24.7	46.0	---	---
2200	22.0	27.1	49.4	---	---
2400	17.6	29.8	47.5	---	---
2600	13.6	32.5	45.6	---	---
2800	10.7	34.6	42.9	---	---
3000	8.4	36.0	39.6	---	---
3400	5.1	38.4	---	6.8	31.9
3800	2.1	38.7	---	6.5	23.3
4200	0.6	37.3	---	6.1	1.4
4600	0.3	34.7	---	5.9	1.1
5000	0.2	32.2	---	5.7	0.8
5400	0.1	29.3	---	5.5	0.5
5800	0.1	26.5	---	5.4	0.4
6200	0.1	24.0	---	5.2	0.2
6600	0.0	21.8	---	5.1	0.1
7000	0.0	19.7	---	4.9	0.1
7400	0.0	17.9	---	4.7	0.0
7800	0.0	16.4	---	4.5	0.0
8200	0.0	14.7	---	4.4	0.0
8600	0.0	13.4	---	4.2	0.0
9000	0.0	12.1	---	4.0	0.0
9400	0.0	10.9	---	3.9	0.0
9800	0.0	10.0	---	3.7	0.0
10400	0.0	8.7	---	3.5	0.0
11000	0.0	7.6	---	3.2	0.0

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Above Sunrise Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 3	XS 4	XS 5	XS 6	XS 7
1000	3	1.9	0.1	106.9	43.8
1200	9	5	0.1	126.3	52.6
1400	14	9.6	0.1	144.2	59.6
1600	16	15.4	0.1	157.1	65.2
1800	16.3	21.8	0.1	166.8	69.7
2000	15.1	27.9	0.1	172.8	73.4
2200	13.9	33.5	0.1	177.6	76.2
2400	12.7	37.7	0.1	180.4	78.3
2600	11.6	40.1	0.1	181.7	79.2
2800	10.9	42.3	0.1	182.3	79.7
3000	10.1	43.7	0.1	181.7	79.5
3400	11.4	44.5	0.1	178.4	77.5
3800	11.3	43.3	0.2	172.9	74.4
4200	11.3	41.5	0.2	54.2	21.1
4600	11.4	38	0.2	51.8	19.7
5000	11.9	33.7	0.2	48.6	17.7
5400	12.4	29.3	0.1	44.3	15.6
5800	12.7	24.8	0.1	40.5	13.5
6200	13.3	21.3	0.1	36.3	11.7
6600	13.9	18.3	0.1	32.5	10.7
7000	15	15.8	0.1	29.1	10.2
7400	17	13.3	0.1	26.3	9.7
7800	19	11.4	0.1	23.6	9
8200	21.2	9.8	0.1	21	8.5
8600	23.3	8.2	1.2	18.8	7.8
9000	25.6	6.9	2.7	17.1	7
9400	28.1	5.8	4.9	15.4	6.3
9800	30.3	4.9	7.9	13.7	5.2
10400	32.9	3.8	15.6	11.5	4.8
11000	34.9	3	24.0	9.9	4.2

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Above Sunrise Study Site - Steelhead Spawning

Flow	XS 1 LC	XS 1 RC	XS 2	XS 2 LC	XS 2 RC
1000	15.0	10.9	7.5	---	---
1200	15.0	11.7	11.5	---	---
1400	14.7	11.6	15.3	---	---
1600	14.5	10.7	18.7	---	---
1800	14.2	11.6	19.4	---	---
2000	13.7	11.5	19.3	---	---
2200	13.0	12.4	19.6	---	---
2400	12.1	13.7	19.9	---	---
2600	10.9	14.2	19.4	---	---
2800	9.5	15.1	18.4	---	---
3000	8.4	14.8	17.4	---	---
3400	6.1	13.9	---	2.6	15.1
3800	3.0	12.5	---	2.3	11.4
4200	1.0	11.4	---	2.0	0.0
4600	0.5	10.8	---	1.7	0.0
5000	0.2	10.3	---	1.6	0.0
5400	0.2	9.8	---	1.6	0.0
5800	0.1	9.3	---	1.5	0.0
6200	0.0	8.7	---	1.5	0.0
6600	0.0	8.2	---	1.5	0.0
7000	0.0	7.5	---	1.5	0.0
7400	0.0	7.3	---	1.5	0.0
7800	0.0	6.9	---	1.5	0.0
8200	0.0	6.6	---	1.5	0.0
8600	0.0	6.2	---	1.5	0.0
9000	0.0	5.8	---	1.5	0.0
9400	0.0	5.4	---	1.5	0.0
9800	0.0	5.1	---	1.5	0.0
10400	0.0	4.6	---	1.5	0.0
11000	0.0	4.2	---	1.5	0.0

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Above Sunrise Study Site - Steelhead Spawning

Flow	XS 3	XS 4	XS 5	XS 6	XS 7
1000	3.8	4.3	0.3	76.4	37.5
1200	3.8	7.8	0.3	76.6	37.7
1400	4	8.6	0.3	76.3	37.2
1600	3.9	8.3	0.3	76.3	36.2
1800	3.8	7.5	0.3	75.6	35.1
2000	3.9	6.8	0.4	75	33.7
2200	4	6.2	0.4	73.8	32.3
2400	4	5.8	0.4	73.8	30.5
2600	3.7	5.7	0.4	72.2	29.3
2800	3.3	6.1	0.4	70.2	28.3
3000	3.3	6.1	0.4	67.9	27.4
3400	4.4	6.1	0.4	62.6	25.8
3800	4.5	6.2	0.4	59.1	23.6
4200	4.5	6.3	0.4	143.4	65.5
4600	4.2	6.5	0.4	116.4	58.7
5000	3.9	6.6	0.4	94.5	52.7
5400	4.1	6.6	0.4	77.3	47.2
5800	4	6.4	0.4	62.3	41.5
6200	3.9	6.1	0.4	50.1	37
6600	4.3	5.6	0.4	41.2	32.2
7000	4.6	5	0.4	33.5	28.4
7400	4.8	4.4	0.4	27.7	24.5
7800	6.7	3.8	0.4	23.4	21.5
8200	7.1	3.5	0.4	20.1	18.8
8600	7.4	3.3	0.4	17.6	16
9000	7.6	2.8	1.3	15.8	13.9
9400	7.7	2.5	2.0	14.7	11.7
9800	7.7	2.1	2.7	13.8	9.8
10400	7.6	1.5	4.3	12.8	8
11000	7.2	1	6.9	12.3	6.2

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sunrise Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 1 LMC	XS 1 RMC	XS 1 SC	XS 2 LMC	XS 2 RMC	XS 2 SC
1000	42.6	---	---	7.4	---	---
1200	41.0	---	---	8.2	---	---
1400	37.2	---	---	8.3	---	---
1600	32.2	---	---	14.3	---	---
1800	26.5	---	---	17.5	---	---
2000	21.2	---	---	16.4	---	---
2200	17.5	---	---	20.9	45.7	---
2400	14.4	---	---	18.1	82.5	---
2600	12.7	---	1.1	14.4	105.3	---
2800	11.8	---	9.1	10.8	117.0	---
3000	11.3	---	19.4	8.7	122.4	4.1
3400	11.9	4.7	12.3	5.4	124.4	2.3
3800	12.1	23.7	7.8	3.0	122.2	0.9
4200	12.5	38.2	9.2	1.6	117.8	0.9
4600	13.2	46.5	14.2	0.7	114.8	0.6
5000	14.1	53.4	20.5	0.3	110.7	2.0
5400	15.0	59.5	22.3	0.1	106.4	3.0
5800	15.9	64.1	21.4	2.2	102.4	4.1
6200	16.7	69.7	21.0	0.0	98.0	53.7
6600	17.4	73.6	20.2	0.0	94.0	62.4
7000	17.9	77.2	21.5	0.0	90.2	70.3
7400	18.2	79.5	23.7	0.0	86.2	76.9
7800	18.4	81.1	25.4	0.0	82.8	83.1
8200	18.5	81.7	26.8	0.0	79.4	88.2
8600	18.7	80.4	28.3	0.0	76.4	92.8
9000	18.8	78.2	29.8	0.0	73.3	96.4
9400	18.9	75.6	31.3	0.0	69.9	98.4
9800	19.1	73.0	35.3	0.0	66.6	99.6
10400	19.3	68.4	32.9	0.0	62.3	100.1
11000	19.5	63.0	32.0	0.0	58.5	100.7

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sunrise Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 3	XS 4	XS 5	XS 6	XS 7
1000	110.0	167.6	98.7	99.6	143.7
1200	119.0	188.9	103.8	106.2	157.9
1400	122.2	200.6	103.5	111.9	166.2
1600	120.3	203.3	100.2	109.2	168.9
1800	114.8	201.0	95.6	107.6	167.9
2000	106.8	196.0	90.3	107.5	163.5
2200	96.9	189.5	88.2	121.1	160.9
2400	87	182	83.7	122.5	157.2
2600	76.4	173.6	79.6	123.8	153.6
2800	67	164.8	75.8	123.8	150.9
3000	58.7	156.9	72	112	148.6
3400	44.9	138.7	64.8	104.5	138.6
3800	36.9	121.5	58.6	98.1	126.1
4200	34.1	106.2	53.0	92.6	114.1
4600	35.7	93	48.2	87	102
5000	40.5	81.7	44.9	82.2	90.7
5400	47.2	72.0	42.5	76.3	81.3
5800	53.3	64.4	40.6	70.6	72.2
6200	58.5	56.9	39.4	64.9	64.0
6600	62.8	51	38.9	59.2	56.7
7000	66.6	46.0	38.5	53.9	50.5
7400	69.9	41.9	38.4	49.0	44.9
7800	73	38	38.7	44.6	40.2
8200	76.2	34.8	39	40.4	36.2
8600	79.1	31.8	39.6	36.6	32.4
9000	81.8	29.1	40.3	33.0	29.3
9400	84	27	41.1	30.1	26.9
9800	86.8	25.1	42	27.1	24.5
10400	90.8	22.2	43.3	23.7	21.6
11000	94.8	20.1	44.5	20.5	19.3

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sunrise Study Site - Steelhead Spawning

Flow	XS 1 LMC	XS 1 RMC	XS 1 SC	XS 2 LMC	XS 2 RMC	XS 2 SC
1000	17.2	---	---	4.1	---	---
1200	14.7	---	---	3.2	---	---
1400	13.1	---	---	2.4	---	---
1600	11.9	---	---	2.8	---	---
1800	13.1	---	---	4.5	---	---
2000	13.2	---	---	5.5	---	---
2200	13.0	---	---	8.6	26.7	---
2400	12.8	---	---	8.2	32.6	---
2600	11.9	---	3.5	7.6	36.1	---
2800	11.3	---	7.1	6.9	37.5	---
3000	10.6	---	5.9	6.1	37.6	0.0
3400	11.5	1.0	7.8	5.1	36.9	1.1
3800	11.3	5.6	6.1	3.9	35.1	0.4
4200	12.5	8.3	5.2	2.6	33.0	0.3
4600	14.9	13.4	5.0	1.6	31.7	0.2
5000	18.1	16.2	5.2	1.1	30.4	0.3
5400	20.3	17.6	6.4	0.7	29.2	0.9
5800	22.1	18.0	7.6	6.2	27.9	1.5
6200	23.2	18.4	8.4	0.3	26.9	16.5
6600	23.8	18.2	8.4	0.2	25.8	19.3
7000	24.3	17.8	7.8	0.1	24.9	21.4
7400	24.7	17.6	8.7	0.0	24.1	22.1
7800	25.1	17.5	9.7	0.0	23.4	22.6
8200	25.6	17.2	10.9	0.0	22.7	23.0
8600	26.1	16.9	11.5	0.0	22.1	23.2
9000	26.6	16.7	11.5	0.0	21.6	23.4
9400	27.1	16.6	10.9	0.0	21.1	23.3
9800	27.2	16.4	11.4	0.0	20.9	23.2
10400	27.2	16.1	8.9	0.0	20.4	22.8
11000	27.2	15.7	8.3	0.0	19.9	22.8

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Sunrise Study Site - Steelhead Spawning

Flow	XS 3	XS 4	XS 5	XS 6	XS 7
1000	35.8	58.8	39.5	32.2	37.8
1200	34.5	58.6	39.1	35.7	40.2
1400	34.5	56.9	41.8	37.4	41.8
1600	34.3	55.5	42.9	37.4	42.7
1800	34.2	55.0	43.0	37.7	42.9
2000	34.5	55.3	42.1	37.6	43.3
2200	34.5	54.6	43.4	41.6	44.8
2400	34.3	54.3	43.5	43.7	47.2
2600	33.9	53.6	42.9	44.7	48.2
2800	34.4	52.6	42.5	46.4	49.3
3000	35.2	51.9	42	43.5	49.6
3400	40.2	49.9	40.2	44.8	49.4
3800	42.5	47.7	37.6	44.1	48.5
4200	42.3	45.4	35.9	42.2	47.4
4600	42.1	42.1	34.8	38.5	45.8
5000	41.9	38	34.9	34.6	43.7
5400	43.7	33.5	34.8	31	40.8
5800	45.8	29.7	35.0	28.5	37.9
6200	48.6	26	34.9	26.5	35.3
6600	52.8	22.8	34.7	24.7	32.3
7000	55.9	21.3	35	23.2	29.9
7400	57.5	20.4	35.2	21.7	27.2
7800	58.2	19.5	35.8	20.4	24.8
8200	59	18.5	36.3	19.4	22.9
8600	58.8	17.4	36.8	18.6	21.2
9000	59.0	16.3	37.1	18.2	19.6
9400	58.9	15.4	38.0	17.8	18.0
9800	58.3	14.4	38.3	17.2	16.3
10400	58.2	12.9	38.5	16.2	14.2
11000	57.3	11.5	38.4	15	12.5

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

El Manto Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 1	XS 2
1000	87.1	49
1200	87.7	44.7
1400	84	41.2
1600	81.3	38.9
1800	74.9	37.5
2000	66.7	34.8
2200	58.7	34
2400	52	32.2
2600	47.1	29.6
2800	43.1	27.5
3000	40.6	24.8
3400	37.1	20
3800	35.9	16.3
4200	34.8	16.5
4600	36.6	15.7
5000	39.2	14.7
5400	41.1	13.5
5800	42.9	12.1
6200	44.4	10.7
6600	45.7	9.2
7000	47	7.9
7400	47.7	7
7800	48.8	5.7
8200	49.2	4.9
8600	49.4	4.1
9000	49.4	3.5
9400	49.8	2.9
9800	50	2.4
10400	49.8	1.8
11000	49.4	1.4

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

El Manto Study Site - Steelhead Spawning

Flow	XS 1	XS 2
1000	25.2	15.3
1200	25.5	14.6
1400	25.6	13.7
1600	26.1	12.6
1800	26.5	12.4
2000	26.4	12.5
2200	25.1	12.2
2400	23.4	11.8
2600	21.3	12.1
2800	18.8	11.4
3000	16.9	10.9
3400	14	11.1
3800	12.3	10.1
4200	12.1	7.9
4600	12.8	6.7
5000	13.5	5.6
5400	14	4.7
5800	15	4
6200	15.2	3.4
6600	15	2.8
7000	15.6	2.3
7400	15.4	1.9
7800	15.1	1.8
8200	15.9	1.7
8600	15.9	1.6
9000	15.8	1.6
9400	15.5	1.6
9800	16.4	1.6
10400	16.4	1.6
11000	16.2	1.4

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Rossmoor Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 1 LC	XS 1 RC	XS 2 LC	XS 2 RC
1000	25.3	22.9	0.7	57.3
1200	28.0	23.6	1.1	53.7
1400	28.3	21.5	1.7	51.4
1600	29.1	18.5	2.4	49.5
1800	28.6	15.2	3.6	48.0
2000	27.5	11.6	5.5	47.7
2200	27.0	8.9	7.9	47.8
2400	25.9	8.2	10.8	47.6
2600	25.1	6.6	14.4	47.0
2800	24.6	5.3	18.2	45.8
3000	23.7	4.1	22.0	44.3
3400	20.8	3.0	29.7	39.4
3800	19.1	2.2	37.8	35.1
4200	18.3	2.5	38.8	29.1
4600	18.2	2.4	36.8	24.7
5000	17.9	2.6	32.9	20.3
5400	17.7	2.8	28.6	17.0
5800	18.0	3.0	25.1	14.4
6200	17.3	3.1	21.7	12.2
6600	16.7	3.1	18.7	10.6
7000	15.9	3.2	16.4	9.3
7400	15.0	2.2	14.6	8.8
7800	14.0	1.1	12.9	9.6
8200	12.9	0.6	11.7	8.8
8600	12.1	0.2	10.7	9.0
9000	11.2	0.0	9.9	9.1
9400	10.4	0.0	9.2	10.0
9800	9.6	0.0	8.6	11.0
10400	8.5	0.0	7.9	12.4
11000	7.6	0.6	7.3	13.5

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Rossmoor Study Site - Fall-run Chinook Salmon Spawning

Flow	XS 3	XS 4	XS 5	XS 6	XS 7
1000	88.6	87.6	156.4	147.8	168
1200	95.4	84.1	171.7	154.0	190.7
1400	93.8	75.6	179.8	152.3	203.7
1600	87.8	66.1	179.4	146.8	207.6
1800	78.5	58.2	174.1	141.1	205.2
2000	69.5	51.4	164.2	134.3	197.8
2200	62	45.9	153.2	126.6	187.6
2400	56.4	41.8	140.3	120.1	176.5
2600	53.3	38.5	128.8	113.3	164.2
2800	52.9	35.9	119.5	107.2	151.3
3000	51.1	33.9	107.9	100.7	138.2
3400	43.5	30.5	90.3	90	112.9
3800	32.7	27.7	77.0	81.3	89.7
4200	23.1	25.5	65.7	70.7	68.1
4600	16.2	23.2	57.1	61.1	56.7
5000	12.2	21.2	50.1	52.5	47.6
5400	10.1	19.3	44.2	45.1	39.8
5800	9.3	17.6	39.0	38.6	33.2
6200	8.8	16.1	34.9	33.2	27.2
6600	8.7	14.7	31.2	28.3	22.3
7000	8.6	13.3	27.4	24.2	18.2
7400	8.6	12.1	24.1	20.7	15.1
7800	8.7	11.1	23.5	17.7	12.5
8200	8.7	10.2	21.7	14.9	10.3
8600	8.7	9.4	19.0	12.8	8.3
9000	8.7	8.7	16.7	11.0	7
9400	8.7	8.1	14.6	9.4	5.9
9800	8.6	7.6	12.5	8.2	5
10400	8.4	6.8	9.7	6.5	4.1
11000	8.2	6.2	7.8	5.3	3.4

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Rossmoor Study Site - Steelhead Salmon Spawning

Flow	XS 1 LC	XS 1 RC	XS 2 LC	XS 2 RC
1000	5.7	4.9	0.0	19.4
1200	6.7	6.1	1.6	18.0
1400	7.7	7.0	2.8	16.8
1600	8.8	7.3	4.0	16.4
1800	10.0	6.8	6.6	16.6
2000	9.9	5.6	8.6	16.4
2200	10.3	4.4	9.6	16.6
2400	10.0	3.4	12.4	16.6
2600	9.5	2.8	13.3	16.8
2800	9.1	2.5	13.7	16.8
3000	9.2	2.1	14.7	16.9
3400	7.0	1.8	14.4	15.6
3800	7.0	1.3	12.5	14.9
4200	6.8	0.8	11.4	13.7
4600	6.0	0.8	11.4	11.9
5000	5.2	0.9	10.8	10.3
5400	4.7	1.0	10.2	8.3
5800	4.6	1.0	9.6	6.4
6200	4.3	1.1	9.1	5.4
6600	4.2	1.2	8.6	4.7
7000	4.1	1.2	8.4	4.2
7400	4.0	1.3	8.3	3.4
7800	3.9	1.3	8.0	3.7
8200	3.7	0.8	7.5	3.4
8600	3.5	0.3	6.9	3.1
9000	3.3	0.0	6.2	3.3
9400	3.1	0.0	5.6	3.2
9800	3.0	0.0	4.9	3.4
10400	2.7	0.0	4.3	3.6
11000	2.5	0.0	3.9	3.6

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).

Rossmoor Study Site - Steelhead Salmon Spawning

Flow	XS 3	XS 4	XS 5	XS 6	XS 7
1000	25.7	30.9	36.1	32.4	48.9
1200	24.9	31.6	38.8	32.4	46.0
1400	26.3	30.8	40	31.9	45.5
1600	26.6	28.6	40.9	31.6	45.1
1800	27.9	25.8	40.9	31.8	44.4
2000	28.2	22.6	41.1	32.0	43.8
2200	28.1	18.9	40.8	32.1	43.5
2400	28.1	15.9	40.1	31.6	43.1
2600	27.3	13.4	40.1	31.3	42.3
2800	24.8	11.8	39.3	30.8	41.9
3000	22.7	10.2	38.3	30.3	40.8
3400	18.0	8.9	35.5	29	38.5
3800	15.4	8.2	32.1	27.6	36.4
4200	14.2	7.7	27.8	26.2	32.5
4600	11.7	7.2	23.7	24.6	29.2
5000	9	6.7	20.6	22.8	25.9
5400	6.8	6.3	17.7	21	22.3
5800	5.7	5.9	15.4	18.9	18.8
6200	4.9	5.6	13.8	17.1	15.7
6600	4.1	5.4	12.6	15	13.2
7000	3.6	5.1	11.7	13.3	11.3
7400	3.3	5.0	10.8	11.3	9.5
7800	3.5	4.8	11.1	9.9	7.9
8200	3.8	4.8	10.9	8.9	6.5
8600	4.0	6.1	10.4	8.4	5.6
9000	3.9	6.7	9.8	7.9	4.8
9400	3.8	6.7	9.3	7.4	4.0
9800	3.8	6.7	9	7.1	3.4
10400	3.7	6.8	8.2	6.6	2.4
11000	3.7	6.9	7.5	6	1.8

Data in above table is Weighted Useable Area (1000 square feet per 1000 feet of stream) for the criteria set in Appendix D. Flow is release from Nimbus Dam (cfs).